CTSW-RT-02-055

CALTRANS CONSTRUCTION SITES RUNOFF CHARACTERIZATION STUDY

MONITORING SEASONS 1998-2002

SEPTEMBER 2002

Prepared for:

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Executive Summary

During four rainy seasons beginning in 1998-1999 and ending in 2001-2002, the California Department of Transportation (Caltrans) has collected storm water quality data from Caltrans construction sites study (CSTW-RT-00-041). One of the primary purposes of the sampling study was to develop a baseline set of construction site storm water quality concentrations.

During the 4-year study, 120 storm events were monitored at 27 sites. Sites were selected to represent a wide range of typical Caltrans construction activities, geographic areas, and hydrometeorologic conditions as well as other site-specific conditions. Sites were monitored according to a sampling and analysis plan which was prepared each year to establish criteria and protocols for conducting storm water monitoring at the selected sites.

Manual sampling was performed to collect samples. Flow-weighted composite samples were collected based on the flow volume. Flow rates and volumes were measured using a portable flow / velocity meter equipped with a data logger. Sampling was attempted if the storm event was forecast to produce cumulative precipitation greater than 0.3 inches, and the storm event was preceded by at least 24 hours of dry weather.

Data from each of the four sampling seasons as well as the combined data set was analyzed using the Caltrans data analysis tool (2001) to determine the minimum and maximum values as well as the mean and coefficient of variance. Use of this tool allowed for proper consideration of data that was reported below the detection limit. The summary of this data is presented in Table ES-1. The results were reviewed to compare annual means of individual parameters for the four reporting years. These comparisons are illustrated in Figures ES-1 through ES-4.

Based on the comparison of the seasonal mean values, the following general observations were made:

Total Metals

- Mean concentrations of Total Lead, Nickel, and Zinc varied over the 4-year period.
- Mean concentrations of Total Copper, Cadmium, and Arsenic were relatively consistent over the study period.
- Mean concentrations of Total Copper have been lower each year since the first year of sampling.
- Mean concentrations of all monitored total metals were lower in the fourth monitoring year than in the first monitoring year, with the exception of Lead.

Table ES-1
Construction Site Analytical Results for Past Four Years (1998-1999 through 2001-2002)

Constituent	Units	1998-99 Sampling Season				1999-00 Sampling Season				2000-01 Sampling Season				2001-02 Sampling Season				1998-02 Sampling Seasons			
		Min	Max	Mean	CV	Min	Max	Mean	CV	Min	Max	Mean	CV	Min	Max	Mean	CV	Min	Max	Mean	CV
Metals																					
Arsenic Dissolved (2)	ug/L	-	-	-	-	-	-	-	-	0.79	7.19	2.34	0.70	1.13	7.08	1.79	0.97	0.79	7.19	2.12	0.77
Arsenic Total (2)	ug/L	-	-	-	-	-	-	-	-	1.27	23.10	4.82	0.95	0.50	12.80	4.13	0.86	0.50	23.10	4.54	0.88
Cadmium Dissolved (3)	ug/L	-	-	-	-	-	-	-	-	0.59	0.59	-	-	0.24	0.49	-	-	0.24	0.59	-	-
Cadmium Total	ug/L	0.53	10.00	0.54	3.75	0.50	4.10	0.91	1.10	0.22	0.94	0.33	0.61	0.26	1.54	0.44	1.02	0.22	10.00	0.58	2.01
Chromium Dissolved	ug/L	2.40	30.00	6.13	1.30	1.00	14.00	3.99	0.79	1.73	31.30	6.12	1.06	1.45	31.50	6.57	1.18	1.00	31.50	5.66	1.13
Chromium Total	ug/L	7.20	620.00	41.90	2.98	6.80	210.00	54.18	0.98	4.10	100.00	28.44	0.82	2.06	59.10	21.89	0.77	2.06	620.00	38.60	1.83
Copper Dissolved	ug/L	2.10	25.00	7.70	0.73	1.00	24.00	5.63	0.93	1.82	29.80	8.47	0.79	2.71	27.90	7.38	0.91	1.00	29.80	7.29	0.80
Copper Total	ug/L	3.80	810.00	45.20	3.67	15.00	128.00	40.07	0.73	8.12	165.00	30.30	1.12	5.48	71.60	25.59	0.79	3.80	810.00	37.20	2.50
Lead Dissolved (3)	ug/L	0.50	15.00	-	-	1.00	5.00	-	-	1.30	36.50	-	-	1.09	12.70	2.56	1.33	0.50	36.50	1.11	3.90
Lead Total	ug/L	1.30	2300.00	89.01	5.45	1.00	291.00	58.50	1.09	1.58	78.00	22.95	0.78	1.21	84.90	32.06	0.90	1.00	2300.00	56.41	4.92
Nickel Dissolved	ug/L	5.30	6.90	-	-	1.00	15.00	3.50	1.10	1.60	8.82	3.08	0.64	2.50	10.20	4.23	0.62	1.00	15.00	3.16	0.83
Nickel Total	ug/L	5.20	790.00	37.48	4.22	7.00	266.00	59.77	1.21	3.49	72.70	24.48	0.85	2.87	41.60	17.88	0.75	2.87	790.00	37.03	2.48
Silver Dissolved (1)(3)	ug/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver Total (3)	ug/L	0.50	5.80	-	-	1.00	53.00	-	-	-	-	-	-	-	-	-	-	0.50	53.00	-	-
Zinc Dissolved	ug/L	5.30	49.00	12.65	1.09	1.00	80.00	15.30	1.29	5.00	69.80	18.00	0.95	8.15	209.00	30.95	1.82	1.00	209.00	17.50	1.43
Zinc Total	ug/L	6.90	3500.00	179.41	4.08	30.00	609.00	200.13	0.78	24.30	441.00	108.97	0.85	23.50	248.00	91.03	0.77	6.90	3500.00	153.73	2.61
Nutrients																					
Phosphorus Dissolved	mg/L	0.01	0.43	0.08	1.05	0.11	0.87	0.33	0.63	0.03	1.60	0.23	1.66	0.09	0.54	0.24	0.65	0.01	1.60	0.20	1.17
Phosphorus Total	mg/L	0.05	10.70	0.64	3.31	0.11	19.00	1.98	2.12	0.07	11.00	1.02	2.82	0.10	0.60	0.34	0.53	0.05	19.00	1.02	2.56
Nitrate (as N)	mg/L	0.15	3.30	0.94	0.80	0.12	3.90	0.82	1.04	0.28	2.80	1.29	0.66	0.12	2.40	0.76	0.90	0.12	3.90	0.95	0.83
Nitrite (as N) (1)(3)	mg/L	0.10	2.80	0.20	2.63	0.25	0.57	-	-	-	-	-	-	-	-	-	-	0.10	2.80	0.16	2.58
Ammonia	mg/L	0.06	4.00	0.48	1.55	0.10	0.80	0.20	0.82	0.10	0.90	0.19	1.23	0.17	1.00	0.20	1.37	0.06	4.00	0.29	1.62
TKN	mg/L	0.30	19.90	2.71	1.40	0.60	12.30	2.14	1.15	0.20	4.60	1.80	0.68	0.56	4.30	1.27	0.85	0.20	19.90	2.11	1.20
Conventionals																					
Hardness	mg/L	13.00	1680.00	107.29	3.15	28.00	660.00	124.37	1.21	46.00	460.00	135.64	0.67	12.00	1600.00	128.00	3.93	12.00	1680.00	121.69	1.91
Suspended Solids	mg/L	12.00	2180.00	258.66	1.69	16.00	3850.00	827.97	1.15	21.00	1710.00	485.39	0.95	14.00	2500.00	355.58	1.91	12.00	3850.00	472.81	1.40
Dissolved Solids	mg/L	22.00	320.00	105.38	0.65	83.00	1270.00	319.83	0.75	63.00	687.00	319.50	0.49	47.00	480.00	200.53	0.59	22.00	1270.00	225.02	0.79
pH	pH Units	6.40	11.40	8.13	0.14	6.60	9.20	7.44	0.08	6.02	9.70	7.65	0.11	6.35	8.14	6.97	0.07	6.02	11.40	7.66	0.12
Specific Conductance	umhos/cm	37.00	490.00	174.00	0.66	20.50	2260.00	318.90	1.82	62.00	2340.00	398.86	1.22	48.00	300.00	130.53	0.61	20.50	2340.00	256.67	1.45
TOC (2)	mg/L	-	-	-	-	-	-	-	-	4.10	45.00	14.05	0.66	3.20	42.00	11.06	1.03	3.20	45.00	12.84	0.77
DOC (2)	mg/L	-	-	-	-	-	-	-	-	2.40	36.00	12.44	0.60	3.80	40.00	9.03	1.13	2.40	40.00	11.06	0.76
COD (1)	mg/L	12.00	150.00	85.58	0.48	28.00	380.00	83.16	1.04	-	-	-	-	-	-	-	-	12.00	380.00	86.06	0.69
Turbidity (1)	NTU	15.00	16000.00	562.49	6.16	72.00	3390.00	984.72	0.81	-	-	-	-	25.00	940.00	392.74	0.86	15.00	16000.00	636.40	3.33
Turbidity, filtered														0.23	140.00	16.70	2.29	0.23	140.00	16.70	2.29
Others																					
Oil & Grease (1)(3)	mg/L	5.00	170.00	8.12	4.56	1.00	4.00	0.67	1.34	-	-	-	-	-	-	-	-	1.00	22.70	2.07	1.75
Coliform Total (1)	MPN/100 ml	2.00	540000.00	52849.76	2.20	20.00	50000.00	5639.71	2.51	-	-	-	-	-	-	-	-	2.00	540000.00	31969.76	2.83
Coliform Fecal (1)	MPN/100 ml	2.00	205000.00	6799.03	7.65	20.00	16000.00	1711.60	2.45	-	-	-	-	-	-	-	-	30.00	240.00	-	-
Chlorpyrifos (1)(3)	ug/L	0.05	0.05	-	-	0.03	0.04	-	-	-	-	-	-	-	-	-	-	0.03	0.05	-	-
Diazinon (1)	ug/L	0.10	2.40	0.42	1.51	0.03	0.20	0.06	0.75	-	-	-	-	-	-	-	-	0.03	2.40	0.22	2.15

Notes:

"-", data set contained majority of non-detect, unable to perform analysis or data not available

(1) Nitrite, Silver, Turbidity, COD, Coliforms, Pesticides and Oil & Grease were not analyzed in 2000-01

(2) Arsenic, TOC and DOC are new for 2000-01

(3) Too many data points below detection limit. Unable to analyze using Caltrans statistical tool.

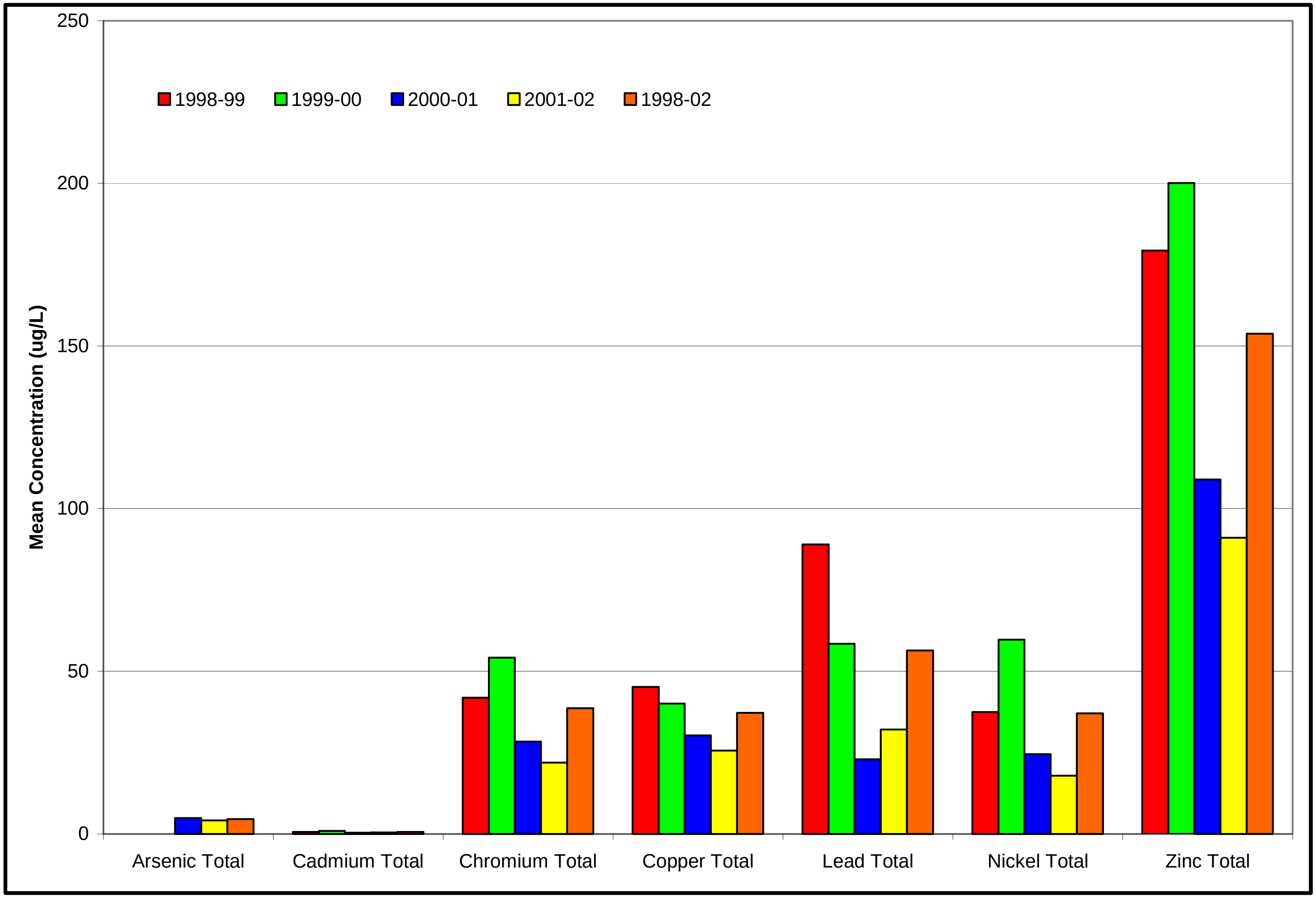


Figure ES-1
Comparison of Total Metals Mean Concentration for
Construction Site Runoff Monitoring During Past Four Years

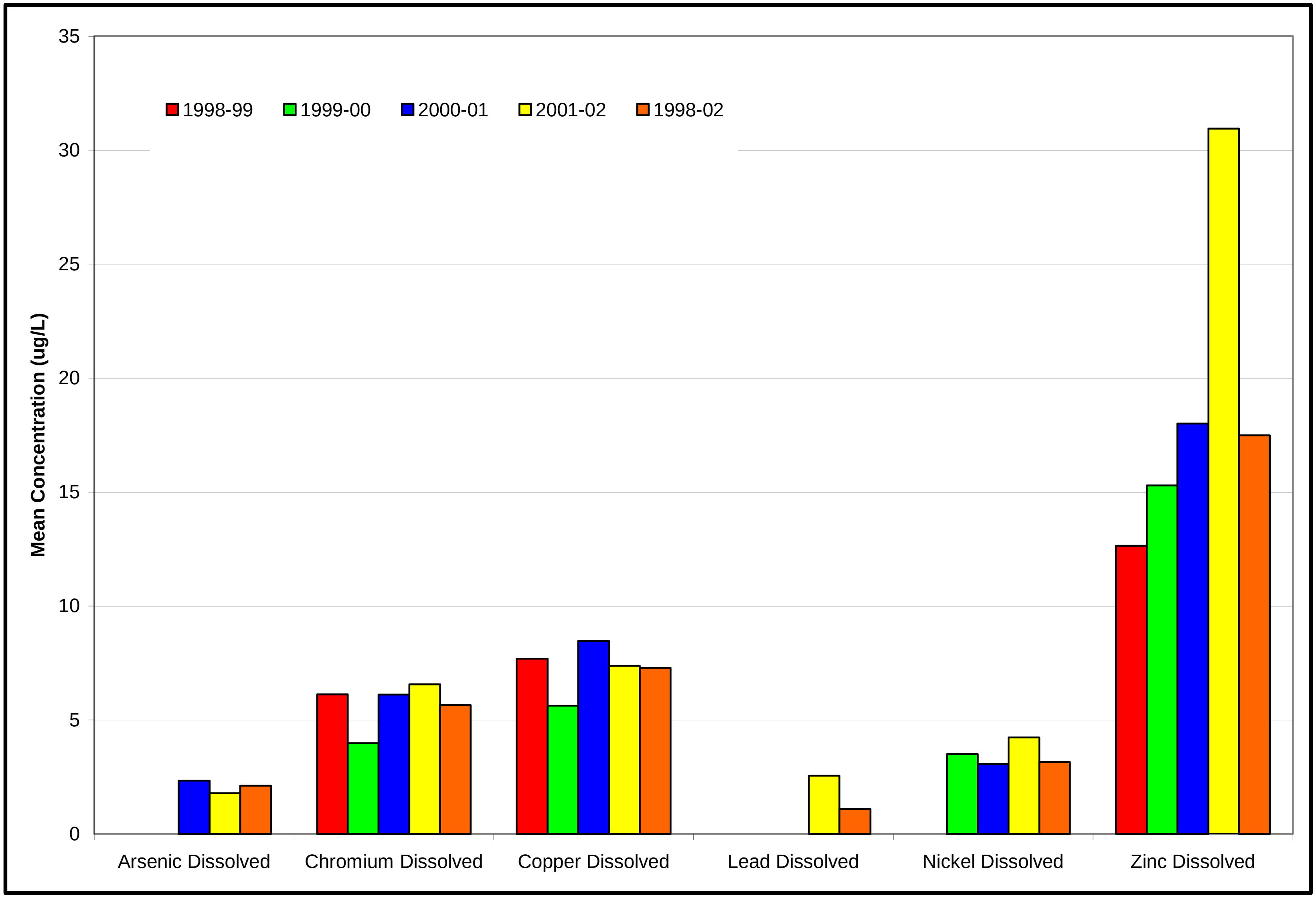


Figure ES-2
Comparison of Dissolved Metals Mean Concentration for
Construction Site Runoff Monitoring During Past Four Years

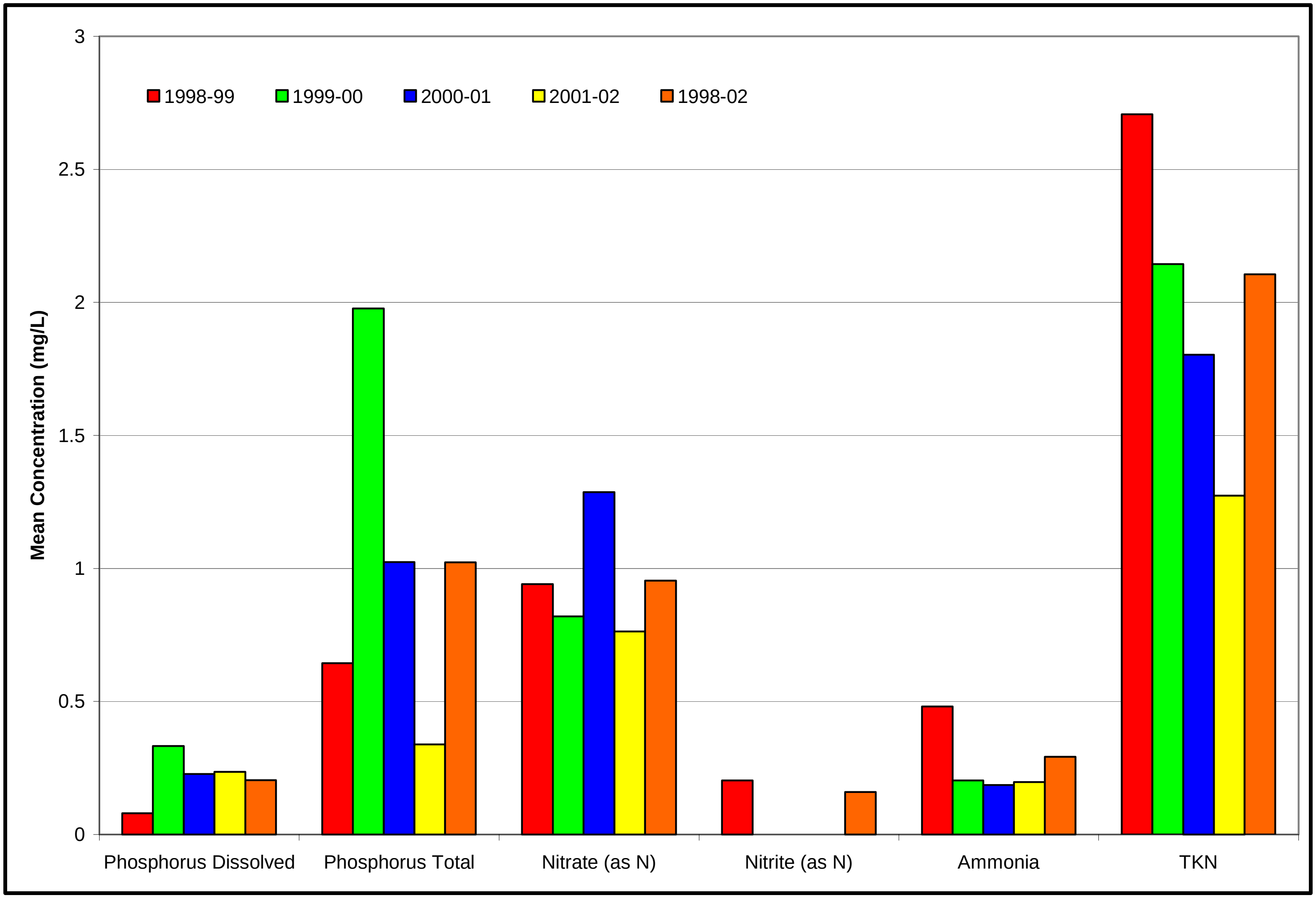


Figure ES-3
Comparison of Nutrients Mean Concentration for
Construction Site Runoff Monitoring During Past Four Years

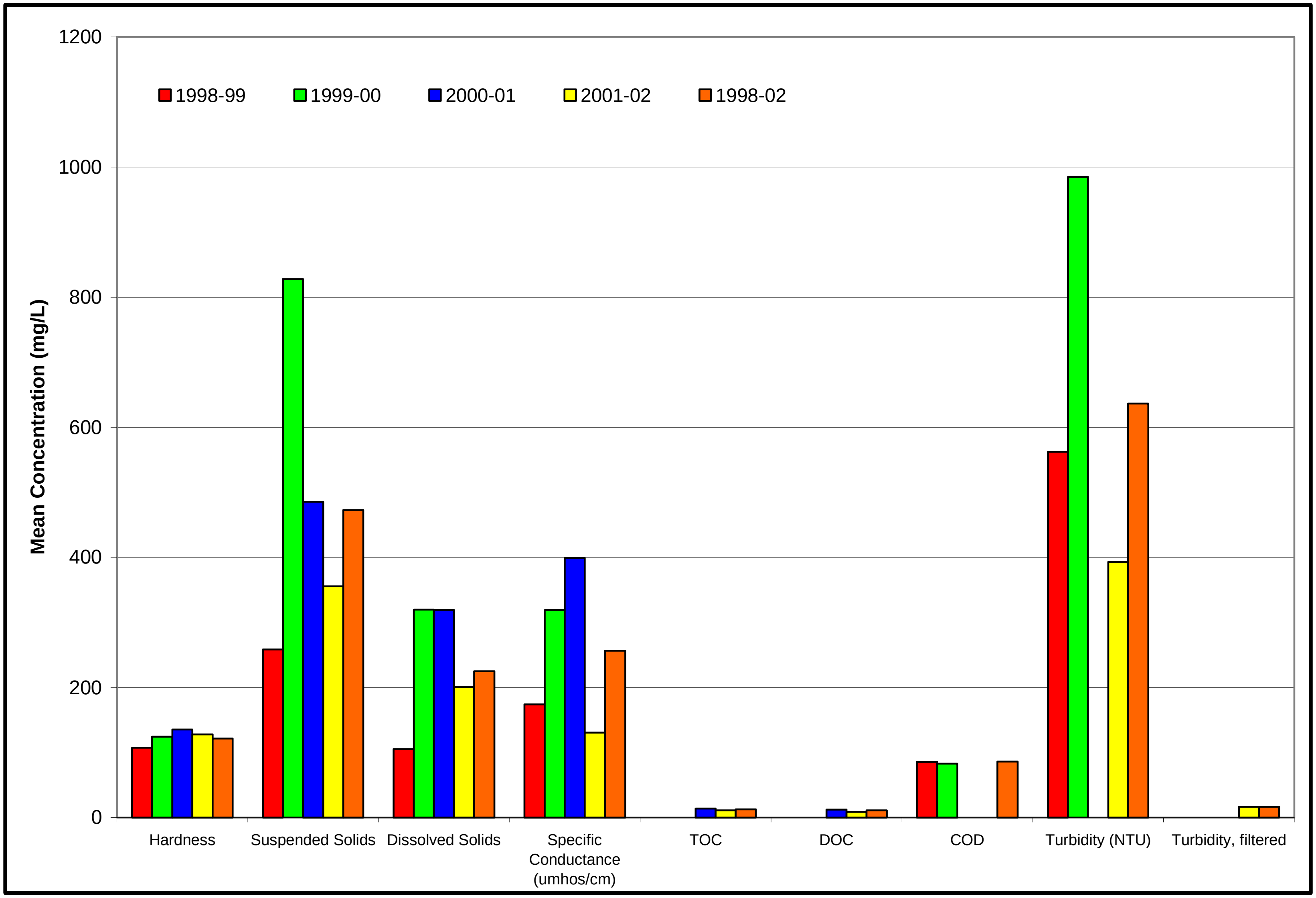


Figure ES-4
Comparison of Conventional Pollutants Mean Concentration for Construction Site Runoff Monitoring During Past Four Years

Dissolved Metals

- Zinc is the only dissolved metal that showed consistently higher observed concentrations in later years.
- Total observed concentrations of other dissolved metals remained relatively consistent over the study period.

Nutrients

- With the exception of TKN, nutrient concentrations have been relatively consistent over the 4-year monitoring period, excluding one abnormally high Total Phosphorous concentration in the second year.
- Observed TKN concentrations have been lower each year over the 4-year study period.
- Total Phosphorous and TKN were lower in the fourth monitoring year compared to other monitoring years.

Conventional Pollutants

- Measured hardness was relatively consistent over the 4-year monitoring period.
- Total Suspended Solids concentrations were much higher during the second monitoring year compared to other monitoring years.
- Total Suspended Solids and Turbidity were closely correlated from year to year as expected since turbidity is primarily caused by suspended solids.
- Total and Dissolved Organic Carbon concentrations are low compared to Dissolved and Suspended Solids suggesting that Dissolved and Suspended Solids are primarily comprised of inorganic particulate matter.

Comparisons were not made for oil and grease, coliform, and pesticides since they were not monitored during the last two seasons.

In addition to comparing means for individual constituents, statistical comparison tests were conducted to provide a method for evaluating whether or not the differences observed between means are statistically significant for (1) new construction versus modification to existing facilities, (2) northern California versus southern California sites, and (3) construction site data versus highway data.

The statistical comparison test showed a statistically significant difference in measured runoff concentrations between new construction and modification to existing facilities for Dissolved Copper, Total Coliform, Dissolved Lead, Dissolved Nickel and Dissolved Zinc, with the concentration of each of these constituents being lower at new construction sites. Comparing water quality runoff from northern California versus southern California sites, the statistical comparison test showed a significant difference for Dissolved Arsenic, Dissolved Chromium, Nitrate, Nitrite, Ammonia, TKN, Dissolved Lead, Dissolved Nickel, Total Nickel, TSS, TOC, and DOC, with the majority of these constituents showing higher concentrations in southern California. Statistical comparisons between seasons showed a significant difference for Dissolved Ortho-Phosphate, Nitrate, Ammonia, Oil and Grease, Diazinon, Total Coliform, Dissolved Zinc, TDS, TSS, pH, and Specific Conductance for one or more seasons compared to other seasons. However, no consistent pattern was observed.

Construction site storm water runoff data was compared to Caltrans highway runoff data. The statistical comparison showed significantly higher concentrations in highway runoff for Total Cadmium, Dissolved Copper, Dissolved Lead, Total Zinc, and Dissolved Zinc. TSS and Hardness were significantly higher in construction site runoff than highway runoff, while oil and grease and COD were significantly higher in highway runoff.

Section 1
Introduction

1.1 Project Objectives

During four rainy seasons beginning in 1998-1999, the California Department of Transportation (Caltrans) has collected storm water quality data from Caltrans construction sites study (CSTW-RT-00-041). One of the primary purposes of the sampling study was to develop a baseline set of construction site storm water quality concentrations. Data generated were intended to meet this objective and to address two key questions:

"Does construction site runoff differ significantly from freeway and highway storm water runoff, and if so, how?"

"Can the constituents found in storm water runoff from construction sites be related to the type of construction project or construction activity?"

The study was conducted during the rainy seasons of the following years:

- 1998-1999
- 1999-2000
- 2000-2001
- 2001-2002

This report will summarize results of the four-year study, including a description of the site selection and monitoring program, a summary of water quality data, and a statistical evaluation of data findings.

1.2 Organization

The report is organized as follows:

- Section 1, Introduction, presents the project objectives and organization of the report.
- Section 2, Site Selection, describes the site selection process and the characteristics and location of those sites chosen.
- Section 3, Monitoring Program, discusses the monitoring equipment used, the sampling process and associated quality control, the constituents being sampled, and a description of the laboratory and analytical methods used.
- Section 4, Water Quality Results, presents a compilation and description of the 1998-2002 water quality data results.

- Section 5, Data Evaluation, compares results from new construction against modifications to existing facilities, northern California sites against southern California sites, and the results of storm water generated at the construction sites against other Caltrans and out of state highway runoff data. In addition, the statistical significance of these findings is discussed.

Section 2
Site Selection

2.1 Site Selection Process

Sites for the four-year study were selected according to several criteria. The selection process used the following general criteria in evaluating the new sites:

- The sites should represent a wide range of typical Caltrans construction activities.
- The sites should represent a wide range of geographic areas.
- The sites should represent a wide range of hydrometeorologic conditions.
- The sites should have construction activity planned to last long enough to monitor over a minimum of one rainy season.

Site specific criteria included:

- Storm water from a significant portion of the construction site should flow to one centralized collection point. The sampling point should be located to obtain runoff as it leaves the construction site.
- The collection point should be part of a conveyance system that concentrates water in a manner that can be monitored for flow. Preferred collection points included catch basins, drain inlets, enclosed pipes, and earthen and asphalt/concrete ditches. Sheet flow is extremely difficult to monitor and was considered inappropriate for this study.
- The collection point should be located in an area where sampling can be safely conducted.
- Sampling equipment and sample collection activities must not interfere with the activities of the construction site.
- Field crews must be able to access the sampling location after-hours and on weekends.
- Construction sites must be active.
- There should be minimal co-mingling of construction site runoff with runoff from offsite or non-construction areas.
- Availability of phone and electrical service is desirable but not necessary.
- The collection point should be located downstream of temporary BMPs used at the site.
- Runoff should eventually flow to an off-site surface water body.

2.2 Final Construction Sites for Monitoring

New sites were located by reviewing each District's database of construction contracts, conferring with Caltrans' consultant performing Storm Water Pollution Prevention Plan (SWPPP) inspections at construction sites, and discussing potential sites with Caltrans headquarters staff and District Resident Engineers. Some sites were able to be monitored for more than one year if construction was active over multiple years. In most cases, several new sites for monitoring had to be identified each year.

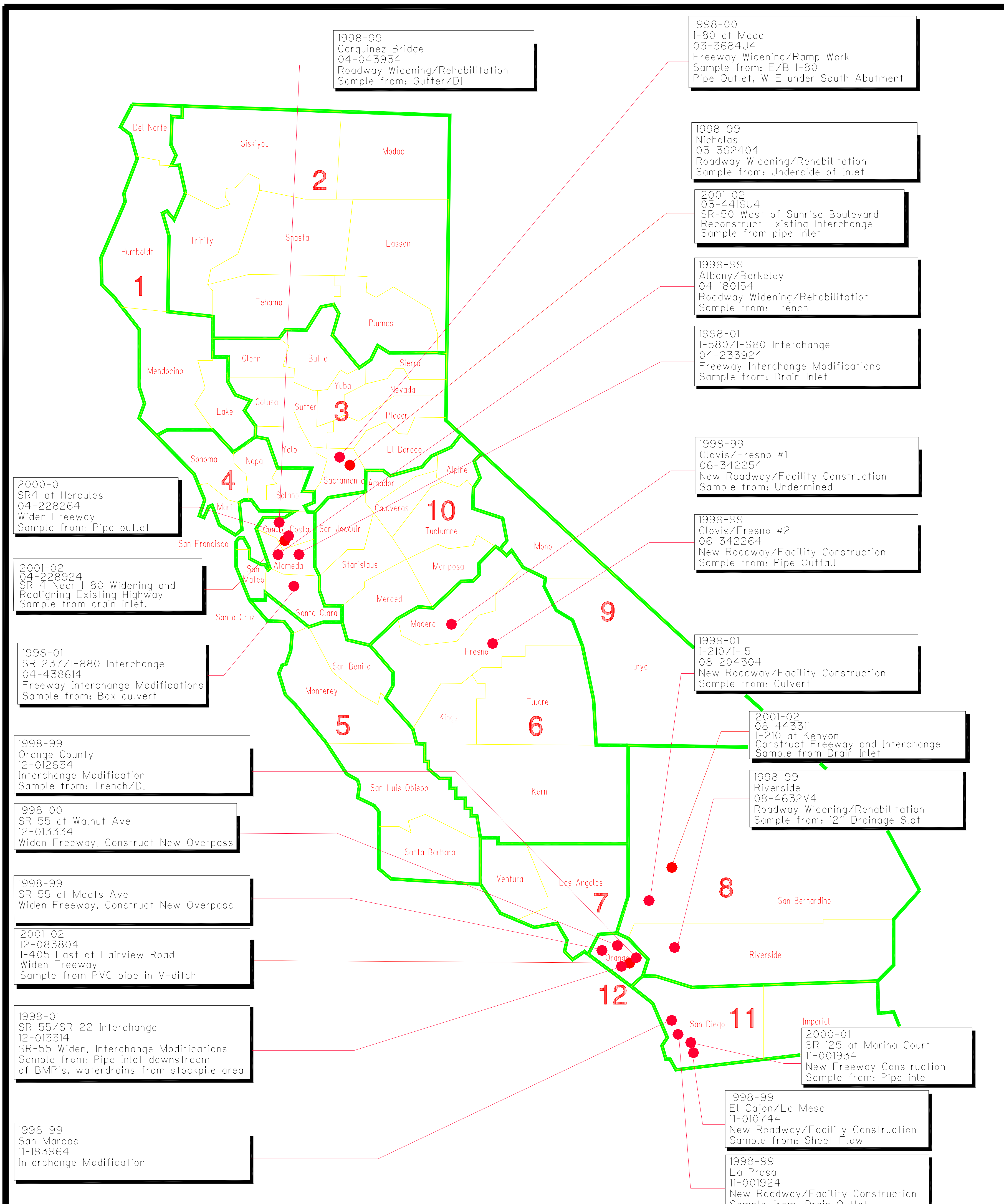
The number of sites monitored each year is shown in Table 2-1.

Table 2-1
Number of Sites Monitored and Storm Events Captured

Year	Number of Sites Monitored
1998-99	17
1999-00	6
2000-01	6
2001-02	4
Total	**33**

Note: Total number of sites exceeds total number on Figure 2-1 and Table 2-3 due to sites being monitored for multiple seasons.

The general locations of 1998-2002 monitoring sites are shown in Figure 2-1. Examples of typical monitoring sites are shown in Photos 2-1 through 2-6.



California Department of Transportation

Construction Site Storm Water Monitoring
1998-2002 Site Locations

Figure 2-1

Photo 2-1
SR-50 at Sunrise Boulevard

Photo 2-2
I-238/ I-880

Photo 2-3
I-580/ I-680

Photo 2-4
SR-55/ SR-22

Photo 2-5
SR-125 at Maria Court

Photo 2-6
SR-125 at Maria Court

The locations of all construction monitoring sites for 1998-2002 by Caltrans district are shown in Table 2-2. Information regarding the 1998-2002 sites is summarized in Table 2-3.

As indicated in Table 2-3, BMPs were present at each of the construction sites, upstream of the monitoring sites. Examples of typical BMPs are shown in Photos 2-7 through 2-13.

Table 2-2
Site Locations by Caltrans District

Caltrans District	Monitoring Season				
	1998-99	1999-00	2000-01	2001-02	SubTotal
1	0	0	0	0	0
2	0	0	0	0	0
3	2	1	0	1	4
4	4	2	3	1	10
5	0	0	0	0	0
6	2	0	0	0	2
7	0	0	0	0	0
8	2	1	1	1	5
9	0	0	0	0	0
10	0	0	0	0	0
11	3	0	1	0	4
12	4	2	1	1	8
Total					33

Note: Total number of sites exceeds total number on Figure 2-1 and Table 2-3 due to sites being monitored for multiple seasons.

Table 2-3

Physical Characteristics 1998-2002 Construction Monitoring Sites

Construction Site-District	Highway	Construction Type	Construction Activities	Sample Location	Flow Measurement	BMP in Place
1-3	I-80	Roadway Widening/ Rehabilitation	Bridge embankment and pier, new entrance ramp	Pipe outlet	Bucket and stop watch	Silt fence, vegetative berms, channel rock
2-3	I-50	Roadway Rehabilitation/ On-Ramp, Off Ramp Modification	New On-Ramp/ Off-Ramp construction, grading of area around ramps	Pipe inlet	Area velocity meter	Inlet protection, soil stabilization
3-3	SR-99	Roadway Widening/ Rehabilitation	Rail replacement, resurfacing	Bridge deck drain	Bucket and stop watch	Gravel bags, filter fabric
4-4	SR-4	Roadway Widening/ Rehabilitation	Grading and paving for widening	Drain inlet	Area velocity meter	Sand bags, inlet protection
5-4	I-80/ SR-580	Roadway Widening/ Rehabilitation	Heavy equipment work on highway supports	Drain inlet	Area velocity meter	Sand bags, silt fence, gravel bags
6-4	SR-4	Widen Freeway	Grading, demolition	Pipe outlet before discharge to Telephone Creek	Area-Velocity/ On-site rain gage	Silt fences, hydroseed, fiber roll, hay bale
7-4	I-580/I-680	Modify Freeway Interchange	Heavy equipment work on highway/bridge supports	Bottom of drop inlet	Area-Velocity/ On-site rain gage	Straw bales, silt fence, hydroseed, cover stockpile
8-4	I-237/I-880	Modify Interchange	Heavy equipment work on highway supports	Transition point between box culvert and dirt channel	Area-Velocity/ On-site rain gage	Sandbag, silt fences, straw bales
9-4	I-80	Roadway Widening/ Rehabilitation	Bridge embankment and pier	Gutter	Area velocity meter	Straw bale
10-4	I-580/ I-680	Freeway Interchange Modification	Highway bridge pier, bridge and roadway	Pipe outlet	Area velocity meter	Sand bag dams
11-4	SR-237/ I-880	Freeway Interchange Modification	New interchange with bridge	Drain pipe	Area velocity meter	Sand bag dams, channel rock
12-6	SR-168	Roadway Facility Construction	Mass grading	Concrete vault	Area velocity meter	Concrete vault with steel grate cover
13-6	SR-168	Roadway Facility Construction	Mass grading, wood work	Drain inlet	Area velocity meter	Silt fence, sand bags

Table 2-3

Physical Characteristics 1998-2002 Construction Monitoring Sites

Construction Site-District	Highway	Construction Type	Construction Activities	Sample Location	Flow Measurement	BMP in Place
14-8	I-210	New Freeway Construction	Heavy equipment work on mass grading, excavation, and paving	Drain inlet	Area velocity meter	Sand bags, gravel bags
15-8	I-15/ SR-210	New Highway Construction	Site grading for new highway, Complete roadway surfacing, grading	Outlet of pipe discharging into concrete trapezoidal channel	Area-Velocity/ On-site rain gage	Silt fence, sand bags, straw bales
16-8	I-15/ SR-215	Roadway Widening/ Rehabilitation	Recent concrete paving	Drain inlet	Bucket and stop watch	Sand bags
17-11	SR-78	Interchange Modification	Roadway excavation, storm drain excavation	30 inch RCP inlet	Area velocity meter	Sand bags
18-11	SR-125 at Maria Court	Construct 4-lane Freeway and interchange	Site grading for new roadway construction	Point before surface flow enters pipe	Area-Velocity/ On-site rain gage	Sand bags, grass swale
19-12	SR-55/SR-22	Widen Existing Highway	Final grading, material stockpile, construction debris	Point at end of grassy swale before runoff enters pipe	Area-Velocity/ On-site rain gage	Silt fence, sand bag, straw bale
20-12	SR-55 at Katella	Widen Existing Highway	Resurfacing, grading	Outlet of pipe crossing under on-ramp	Area-Velocity/On-site rain gage	Sand bags
21-12	I-405/ SR-73	Roadway Widening/ Rehabilitation	Grading and paving for widening	18" corrugated PVC pipe in concrete v-ditch before drain inlet	Area velocity meter	Sand bag dams
22-12	I-5	Roadway Widening/ Rehabilitation	Soil removal, grading, storm drain installation	30 inch RCP inlet	Area velocity meter	Sand bags
23-12	SR-55	Widen Freeway/ Construct Overpass	Grading, street approach, bridge piers and bridge	Pipe outlet	Area velocity meter	Sand bags

Photo 2-7
Silt Fence, Sand Bag, and Rock Berm outlet protection

Photo 2-8
Fiber Rolls installed for erosion control

Photo 2-9
Fiber Rolls and Rock Filter drain inlet protection and soil binder

Photo 2-10
Sand Bag drain inlet protection

Photo 2-11
Straw Bale sediment control

Photo 2-12
Silt Fence

Photo 2-13
Straw Bale sediment control

Section 3
Monitoring Program

3.1 Monitoring Plan

3.1.1 General

A Sampling and Analysis Plan for the study was prepared each year to establish the criteria and protocols for conducting storm water monitoring at the selected construction sites. This section describes the monitoring equipment used, the sampling process and associated quality control, constituents being analyzed, and the laboratory and analytical methods used for the study. More detailed information on each of these topics is included in the Sampling and Analysis Plans.

3.1.2 Equipment

Flow-weighted composite samples were collected based on the flow volume. Because installation of automatic samplers was not feasible, manual sampling was performed to collect samples. Storm water runoff from construction sites was monitored using a variety of equipment, including:

- Scoops or pole sampler for sample collection
- Area -velocity (AV) flow meter / data logger for flow measurement
- Rain gage for rainfall measurement

The manual collection of flow-weighted samples was performed as described in Section 3.1.4. Flow rates and volumes were measured using a portable flow / velocity meter equipped with a data logger. The technique used to prepare flow-weighted composite samples involved collection of equal-volume sample aliquots at the time of sampling, measurement of flow rates and volumes, followed by flow-proportioning and compositing of aliquots into a single sample for laboratory analysis.

3.1.3 Storm Forecasting and Logistics

Sampling of a rainfall event was attempted if the following criteria were met:

- The storm event was forecast to produce cumulative precipitation greater than 0.3 inch, and
- The storm event was preceded by at least 24 hours of dry weather.
- Due to the uncertainty of dates and times of storm events, sampling activities were not limited to normal business hours.

3.1.4 Composite Sample Collection

Field crews were instructed to collect one, 1 to 4 liter aliquot sample every 20 minutes for up to 8 hours. If the storm was less than 8 hours in duration, aliquot samples were collected every 20 minutes until the end of storm water runoff. Table 3-1 shows the number and volume of aliquot samples collected based on predicted storm duration.

Table 3-1
Sample Aliquot Volumes
Standard Sample and QA/QC Sample Station

Predicted Storm Duration	Aliquot No.	Standard Collection Volume (L)	QA/QC Collection Volume (L)
20 min	1	2	4
40 min	2	2	4
1 hr	3	2	4
1 hr 20 min	4	2	4
1 hr 40 min	5	1	3
2 hrs	6	1	3
2 hrs 20 min	7	1	3
2 hrs 40 min	8	1	3
3 hrs	9	1	2
3 hrs 20 min	10	1	2
3 hrs 40 min	11	1	2
4 hrs	12	1	2
4 hrs 20 min	13	1	1
4 hrs 40 min	14	1	1
5 hrs	15	1	1
5 hrs 20 min	16	1	1
5 hrs 40 min	17	1	1
6 hrs	18	1	1
6 hrs 20 min	19	1	1
6 hrs 40 min	20	1	1
7 hrs	21	1	1
7 hrs 20 min	22	1	1
7 hrs 40 min	23	1	1
8 hrs	24	1	1

The following field data were recorded on Field Data Log Sheets for each station every time an aliquot was collected:

- Time - The time (military time) when sample aliquots were collected.
- Flow Rate (gpm) - The measure of flow at the sample collection point converted to L/S for database.
- Cumulative Flow Volume (gallons) - The volume of water that passed the station from the start of the storm water runoff and converted to liters for database.
- Flow Velocity (ft/s) - The measure of the flow's velocity at the sample collection point.
- pH (pH units) - The measure of pH of the aliquot sample.
- Conductivity (µS/cm) - The measure of specific conductance of the sample aliquot.
- Temperature (° C) - The measure of temperature of the sample aliquot.
- Rain (inches) - The total rainfall in inches since the start of the storm. This is accumulated each time that the rain bucket tips and converted to mm for the database.

Composite samples were developed from individual aliquot samples. Composite samples were prepared on a flow basis with the amount taken from each aliquot calculated from the flow volume during the twenty-minute period and the total flow volume during the storm event. The compositing volumes from each aliquot were calculated by the field crew and prepared at the laboratory.

Specific conductivity, pH, and temperature were measured for each aliquot sample using field equipment (in accordance with the manufacturers' instructions) and results recorded in the designated spaces on the Field Data Log Sheet. Empirical observations made throughout the storm event were recorded on a Field Data Log Sheet.

Manual sample collection was performed at all sites and portable flow/velocity meters and rain gages were used. Each meter and gage was set up and checked for performance upon arrival of the field team and during the storm event.

Manual samples were collected by inserting the sample container under or down current of the storm water discharge, with the container opening facing upstream. Less accessible sampling points required the use of poles and buckets to collect samples. To verify that manual samples were representative of the storm water discharged, the following procedures were followed:

- Vehicle engines were turned off to minimize exposure of samples to exhaust fumes.
- Sample containers were labeled.
- Samples were taken from the horizontal and vertical center of the flow stream.
  - Samples were taken so as not to stir up any sediment at the bottom of a channel.
  - The inside of the sampling container was not touched.
  - Uncharacteristic floating debris was not collected.

Once samples were collected, they were promptly put into a cooler with ice at 4 °C.

3.1.5 Quality Assurance/Quality Control

The analytical data was reviewed using the quality assurance/quality control (QA/QC) procedures. A full discussion of the QA/QC process and features is outlined in the Sampling and Analysis Plan.

3.2 Chemical Constituents and Analytical Methods

The list of constituents analyzed in the four-year study is shown in Table 3-2. Some constituents were dropped and/or added over the years. In 2000-2001, Arsenic, TOC and DOC were added, while Silver, Nitrite, Turbidity, COD, Oil & Grease, Coliforms and Pesticides were dropped. In 2001-2002, Turbidity was added (turbidity of the sample and filtrate). This new constituent list was used to conform with the minimum constituent list in Caltrans Guidance Manual: Storm Water Monitoring Protocols (July 2000).

Analytical laboratory methods for water quality analyses were specified in each year's SAP, and are listed in Table 3-2. Analytical methods and method reporting limits were approved by Caltrans prior to collecting monitoring samples. Table 3-4 lists and compares the reporting limits from the 1998-1999, 1999-2000, 2000-2001, and 2001-2002 monitoring years. Different laboratories were used for monitoring causing some reporting limits to change. Data generated by both laboratories should be comparable since the same analytical methods were used.

Laboratory analyses for 1998-1999 Construction Site Characterization were performed by Montgomery Watson Laboratories and subcontracted laboratories as specified in the Interim Characterization Report 1998-1999.

Laboratory analyses for 1999-2000, 2000-2001 and 2001-2002 Construction Site Characterization were performed by Calscience Environmental Laboratories, Inc. (Calscience), located in Garden Grove, California. Calscience is certified by California Department of Health Services, Environmental Laboratory Accreditation Program

Table 3-2
Selected Analytical Constituents Analytical Methods and Detection Limits

Constituent	Units	Analytical Methods (98/99, 99/00, 00/01, 01/02)	Construction Site Monitoring Detection Limit (98/99)	Construction Site Monitoring Detection Limit (99/00)	Construction Site Monitoring Detection Limit (00/01)	Construction Site Monitoring Detection Limit (01/02)
Metals (1)						
Arsenic	µg/L	EPA 200.8	New for 00/01	New for 00/01	0.5	0.5
Cadmium	µg/L	EPA 200.8	0.5	0.5	0.2	0.2
Chromium	µg/L	EPA 200.8	2	1	1	1
Copper	µg/L	EPA 200.8	2	1	1	1
Lead	µg/L	EPA 200.8	0.5	1	1	1
Nickel	µg/L	EPA 200.8	5	1	2	2
Zinc	µg/L	EPA 200.8	5	1	5	5
Nutrients						
Phosphorus	mg/L	EPA 365.2 or 365.3	0.1	0.1	5	0.03
Dissolved ortho-Phosphate	mg/L	EPA 365.3	0.1	0.1	0.1	0.03
Nitrate	mg/L	EPA 300.0	0.1	0.1	0.1	0.1
Ammonia	mg/L	EPA 350.1 or 350.3	0.05	0.1	0.1	0.1
Total Kjeldahl Nitrogen	mg/L	EPA 351.2 or 351.4	0.2	0.5	0.3	0.3
Conventionals						
Hardness	mg/L	EPA 130.1 or ML/SM 2340	7	2	2	2
Total Suspended Solids	mg/L	EPA 160.2	4	4	1	1
Total Dissolved Solids	mg/L	EPA 160.1 or ML/SM 2540C	10	1	1	1
Total Organic Carbon	mg/L	EPA 415.1	New for 00/01	New for 00/01	1	1
Dissolved Organic Carbon	mg/L	EPA 415.1	New for 00/01	New for 00/01	1	1
Turbidity	NTU	EPA 180.1	1	1	Not analyzed in 00/01	0.05
Field Measurements						
Specific Conductivity	µmho/cm	Field Meter and EPA 120.1	4	1	4	4
pH	PH units	Field Meter and EPA 150.1	0.001	0.01	0.01	0.01
Temperature	ºC	Field Meter	0.1	0.1	0.1	0.1

(1) Dissolved metals were filtered prior to acidification

(ELAP). Calscience follows all QA / QC requirements specified in each analytical method performed, as well as their own internal laboratory QA / QC procedures. Laboratory QA / QC functions were performed by Calscience staff.

For laboratory analysis during the 1999-2000 season, laboratories subcontracted by Calscience to perform specialized analyses (i.e., coliform and pesticide analyses) were also certified by California Department of Health Services. Silliker Laboratories of Southern California, located in Carson, California, was the subcontract laboratory that analyzed samples for total and fecal coliforms; AQUA-Science, located in Davis, California, was subcontracted to analyze samples for diazinon and chlorpyrifos using the ELISA method. For 2000-2001, those constituents were not analyzed so all constituent analyses were performed by Calscience. In 2001-2002, Calscience performed all constituent analyses.

3.3 Storm Events Sampled

Table 3-3 lists the number of storm events monitored in each wet season. The 120 storm events differed in depth and intensity of the rainfall for each construction site contributing to the variances seen in the analytical data. During the 1998-2002 periods, the annual rainfall in Northern and Southern California varied as shown in Table 3-4. Note that Southern California experienced extremely low rainfall amounts during the 2001-2002 seasons. In fact, the 2001-2002 water years were the driest on record for Los Angeles and San Diego.

Table 3-3
Number of Sites Monitored and Storm Events Captured

Year	Number of Sites Monitored	Events Captured
1998-1999	17	43
1999-2000	6	30
2000-2001	6	28
2001-2002	4	19
Total	**33**	**120**

Table 3-4
Annual Rainfall (inches) from 1998 - 2002

Year	Northern California*	Southern California**
1998-1999	23.49	9.12
1999-2000	24.89	11.57
2000-2001	19.47	17.94
2001-2002	24.18	4.42

* Data from San Francisco (July ~ June)
** Data from Los Angeles (July ~ June)

3.4 Data Management and Reporting

Detailed results of the water quality analyses are presented and discussed in Section 4. Water quality data was loaded from electronic laboratory files into Excel spreadsheets consistent with the layout guidelines provided by Caltrans and reporting requirements as specified in the Caltrans Water Quality Data-Reporting Protocols.

After the data was checked, originals were filed in the project file to maintain complete project records. The laboratory also provided data in electronic formats to link directly with the project database with a minimum of editing. A relational database was developed using Microsoft Excel and Microsoft Access to manage all water quality data. Files from the storm water monitoring locations were stored in the same database system and linked to the laboratory database. The datalogger files included rainfall and discharge data. Site characteristics were stored in a separate file and linked to both the chemical and datalogger files in order to enable useful data queries.

Section 4
Water Quality Results
Summary of Results

Data from each of the four sampling seasons as well as the combined data set was analyzed using the Caltrans data analysis tool (2001) to determine the minimum and maximum values as well as the mean and coefficient of variance. Use of this tool allowed for proper consideration of data that was reported below the detection limit. The statistical summary of this data is presented in Table 4-1. The complete set of data for 1998-1999 through 2001-2002 is included in Tables 4–2 through 4-5 at the end of this section. Use of the Caltrans data analysis tool also allowed data from the four monitoring seasons (1998-2002) to be compared on the same basis. It should be noted however, that the analysis of the data shown in Table 4-1 for the previous three years (1998-2001) may differ from those results presented in previous reports where the Caltrans statistical tool was not used. In addition, filtered turbidity is a new analysis added in 2001-2002. Turbidity was also reintroduced in the 2001-2002 season after being previously removed for the 2000-2001 season.

The results were reviewed to compare annual means of individual parameters for the four reporting years. These comparisons are illustrated in Figures 4-1 through 4-4.

From these figures, the following general observations can be made:

Total Metals

- Mean concentrations of Total Lead, Nickel, and Zinc varied over the 4-year period.
- Mean concentrations of Total Copper, Cadmium, and Arsenic were relatively consistent over the study period.
- Mean concentrations of Total Copper have been lower each year since the first year of sampling.
- Mean concentrations of all monitored total metals were lower in the fourth monitoring year than in the first monitoring year, with the exception of Lead.

Dissolved Metals

- Zinc is the only dissolved metal that showed consistently higher observed concentrations in later years.
- Observed concentrations of other dissolved metals remained relatively consistent over the study period.

Table 4-1
Construction Site Analytical Results for Past Four Years (1998-1999 through 2001-2002)

Constituent	Units	1998-99 Sampling Season				1999-00 Sampling Season				2000-01 Sampling Season				2001-02 Sampling Season				1998-02 Sampling Seasons			
		Min	Max	Mean	CV	Min	Max	Mean	CV	Min	Max	Mean	CV	Min	Max	Mean	CV	Min	Max	Mean	CV
Metals																					
Arsenic Dissolved (2)	ug/L	-	-	-	-	-	-	-	-	0.79	7.19	2.34	0.70	1.13	7.08	1.79	0.97	0.79	7.19	2.12	0.77
Arsenic Total (2)	ug/L	-	-	-	-	-	-	-	-	1.27	23.10	4.82	0.95	0.50	12.80	4.13	0.86	0.50	23.10	4.54	0.88
Cadmium Dissolved (3)	ug/L	-	-	-	-	-	-	-	-	0.59	0.59	-	-	0.24	0.49	-	-	0.24	0.59	-	-
Cadmium Total	ug/L	0.53	10.00	0.54	3.75	0.50	4.10	0.91	1.10	0.22	0.94	0.33	0.61	0.26	1.54	0.44	1.02	0.22	10.00	0.58	2.01
Chromium Dissolved	ug/L	2.40	30.00	6.13	1.30	1.00	14.00	3.99	0.79	1.73	31.30	6.12	1.06	1.45	31.50	6.57	1.18	1.00	31.50	5.66	1.13
Chromium Total	ug/L	7.20	620.00	41.90	2.98	6.80	210.00	54.18	0.98	4.10	100.00	28.44	0.82	2.06	59.10	21.89	0.77	2.06	620.00	38.60	1.83
Copper Dissolved	ug/L	2.10	25.00	7.70	0.73	1.00	24.00	5.63	0.93	1.82	29.80	8.47	0.79	2.71	27.90	7.38	0.91	1.00	29.80	7.29	0.80
Copper Total	ug/L	3.80	810.00	45.20	3.67	15.00	128.00	40.07	0.73	8.12	165.00	30.30	1.12	5.48	71.60	25.59	0.79	3.80	810.00	37.20	2.50
Lead Dissolved (3)	ug/L	0.50	15.00	-	-	1.00	5.00	-	-	1.30	36.50	-	-	1.09	12.70	2.56	1.33	0.50	36.50	1.11	3.90
Lead Total	ug/L	1.30	2300.00	89.01	5.45	1.00	291.00	58.50	1.09	1.58	78.00	22.95	0.78	1.21	84.90	32.06	0.90	1.00	2300.00	56.41	4.92
Nickel Dissolved	ug/L	5.30	6.90	-	-	1.00	15.00	3.50	1.10	1.60	8.82	3.08	0.64	2.50	10.20	4.23	0.62	1.00	15.00	3.16	0.83
Nickel Total	ug/L	5.20	790.00	37.48	4.22	7.00	266.00	59.77	1.21	3.49	72.70	24.48	0.85	2.87	41.60	17.88	0.75	2.87	790.00	37.03	2.48
Silver Dissolved (1)(3)	ug/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver Total (3)	ug/L	0.50	5.80	-	-	1.00	53.00	-	-	-	-	-	-	-	-	-	-	0.50	53.00	-	-
Zinc Dissolved	ug/L	5.30	49.00	12.65	1.09	1.00	80.00	15.30	1.29	5.00	69.80	18.00	0.95	8.15	209.00	30.95	1.82	1.00	209.00	17.50	1.43
Zinc Total	ug/L	6.90	3500.00	179.41	4.08	30.00	609.00	200.13	0.78	24.30	441.00	108.97	0.85	23.50	248.00	91.03	0.77	6.90	3500.00	153.73	2.61
Nutrients																					
Phosphorus Dissolved	mg/L	0.01	0.43	0.08	1.05	0.11	0.87	0.33	0.63	0.03	1.60	0.23	1.66	0.09	0.54	0.24	0.65	0.01	1.60	0.20	1.17
Phosphorus Total	mg/L	0.05	10.70	0.64	3.31	0.11	19.00	1.98	2.12	0.07	11.00	1.02	2.82	0.10	0.60	0.34	0.53	0.05	19.00	1.02	2.56
Nitrate (as N)	mg/L	0.15	3.30	0.94	0.80	0.12	3.90	0.82	1.04	0.28	2.80	1.29	0.66	0.12	2.40	0.76	0.90	0.12	3.90	0.95	0.83
Nitrite (as N) (1)(3)	mg/L	0.10	2.80	0.20	2.63	0.25	0.57	-	-	-	-	-	-	-	-	-	-	0.10	2.80	0.16	2.58
Ammonia	mg/L	0.06	4.00	0.48	1.55	0.10	0.80	0.20	0.82	0.10	0.90	0.19	1.23	0.17	1.00	0.20	1.37	0.06	4.00	0.29	1.62
TKN	mg/L	0.30	19.90	2.71	1.40	0.60	12.30	2.14	1.15	0.20	4.60	1.80	0.68	0.56	4.30	1.27	0.85	0.20	19.90	2.11	1.20
Conventionals																					
Hardness	mg/L	13.00	1680.00	107.29	3.15	28.00	660.00	124.37	1.21	46.00	460.00	135.64	0.67	12.00	1600.00	128.00	3.93	12.00	1680.00	121.69	1.91
Suspended Solids	mg/L	12.00	2180.00	258.66	1.69	16.00	3850.00	827.97	1.15	21.00	1710.00	485.39	0.95	14.00	2500.00	355.58	1.91	12.00	3850.00	472.81	1.40
Dissolved Solids	mg/L	22.00	320.00	105.38	0.65	83.00	1270.00	319.83	0.75	63.00	687.00	319.50	0.49	47.00	480.00	200.53	0.59	22.00	1270.00	225.02	0.79
pH	pH Units	6.40	11.40	8.13	0.14	6.60	9.20	7.44	0.08	6.02	9.70	7.65	0.11	6.35	8.14	6.97	0.07	6.02	11.40	7.66	0.12
Specific Conductance	umhos/cm	37.00	490.00	174.00	0.66	20.50	2260.00	318.90	1.82	62.00	2340.00	398.86	1.22	48.00	300.00	130.53	0.61	20.50	2340.00	256.67	1.45
TOC (2)	mg/L	-	-	-	-	-	-	-	-	4.10	45.00	14.05	0.66	3.20	42.00	11.06	1.03	3.20	45.00	12.84	0.77
DOC (2)	mg/L	-	-	-	-	-	-	-	-	2.40	36.00	12.44	0.60	3.80	40.00	9.03	1.13	2.40	40.00	11.06	0.76
COD (1)	mg/L	12.00	150.00	85.58	0.48	28.00	380.00	83.16	1.04	-	-	-	-	-	-	-	-	12.00	380.00	86.06	0.69
Turbidity (1)	NTU	15.00	16000.00	562.49	6.16	72.00	3390.00	984.72	0.81	-	-	-	-	25.00	940.00	392.74	0.86	15.00	16000.00	636.40	3.33
Turbidity, filtered														0.23	140.00	16.70	2.29	0.23	140.00	16.70	2.29
Others																					
Oil & Grease (1)(3)	mg/L	5.00	170.00	8.12	4.56	1.00	4.00	0.67	1.34	-	-	-	-	-	-	-	-	1.00	22.70	2.07	1.75
Coliform Total (1)	MPN/100 ml	2.00	540000.00	52849.76	2.20	20.00	50000.00	5639.71	2.51	-	-	-	-	-	-	-	-	2.00	540000.00	31969.76	2.83
Coliform Fecal (1)	MPN/100 ml	2.00	205000.00	6799.03	7.65	20.00	16000.00	1711.60	2.45	-	-	-	-	-	-	-	-	30.00	240.00	-	-
Chlorpyrifos (1)(3)	ug/L	0.05	0.05	-	-	0.03	0.04	-	-	-	-	-	-	-	-	-	-	0.03	0.05	-	-
Diazinon (1)	ug/L	0.10	2.40	0.42	1.51	0.03	0.20	0.06	0.75	-	-	-	-	-	-	-	-	0.03	2.40	0.22	2.15

Notes:

"-", data set contained majority of non-detect, unable to perform analysis or data not available

(1) Nitrite, Silver, Turbidity, COD, Coliforms, Pesticides and Oil & Grease were not analyzed in 2000-01

(2) Arsenic, TOC and DOC are new for 2000-01

(3) Too many data points below detection limit. Unable to analyze using Caltrans statistical tool.

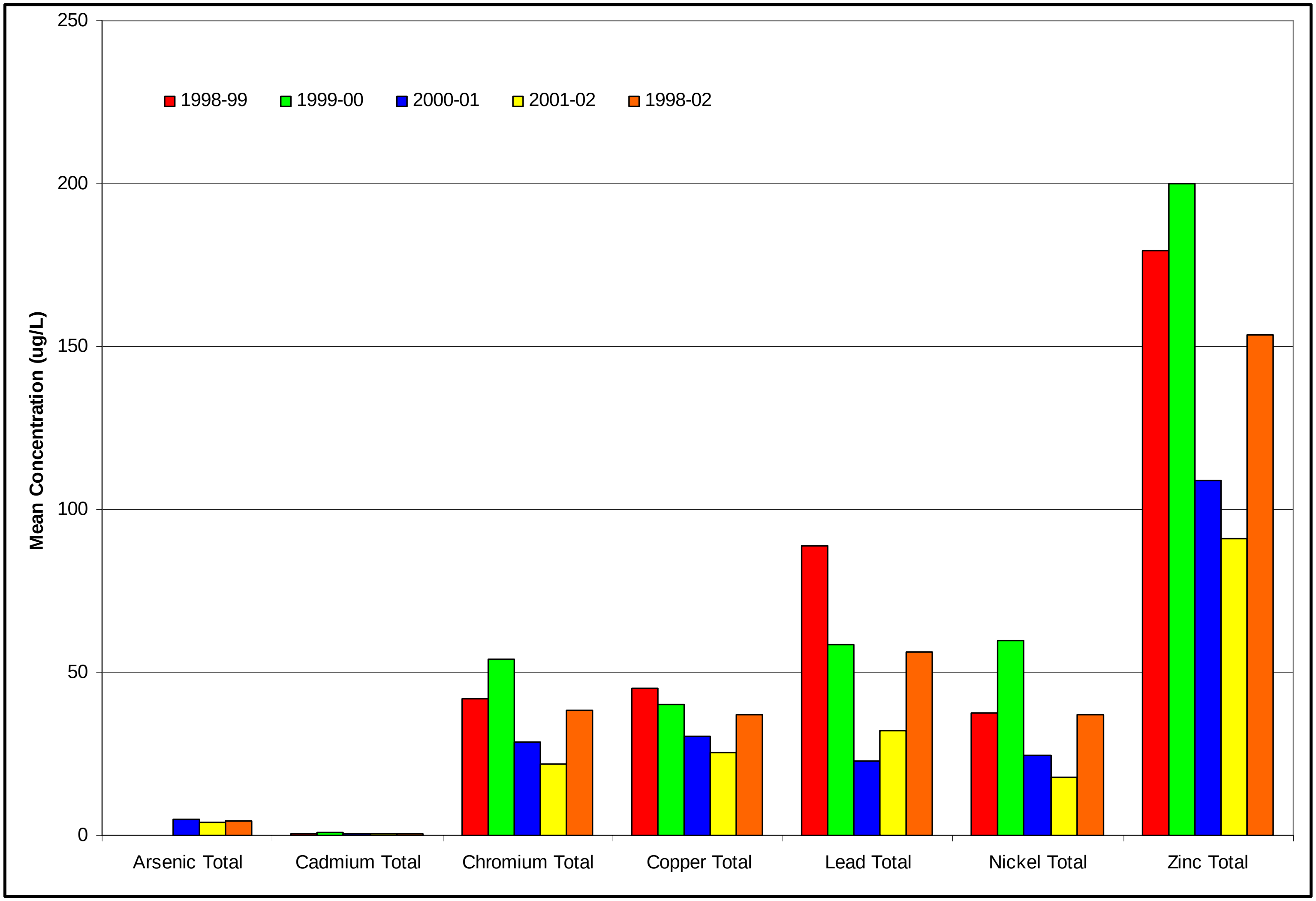


Figure 4-1
Comparison of Total Metals Mean Concentration for
Construction Site Runoff Monitoring During Past Four Years

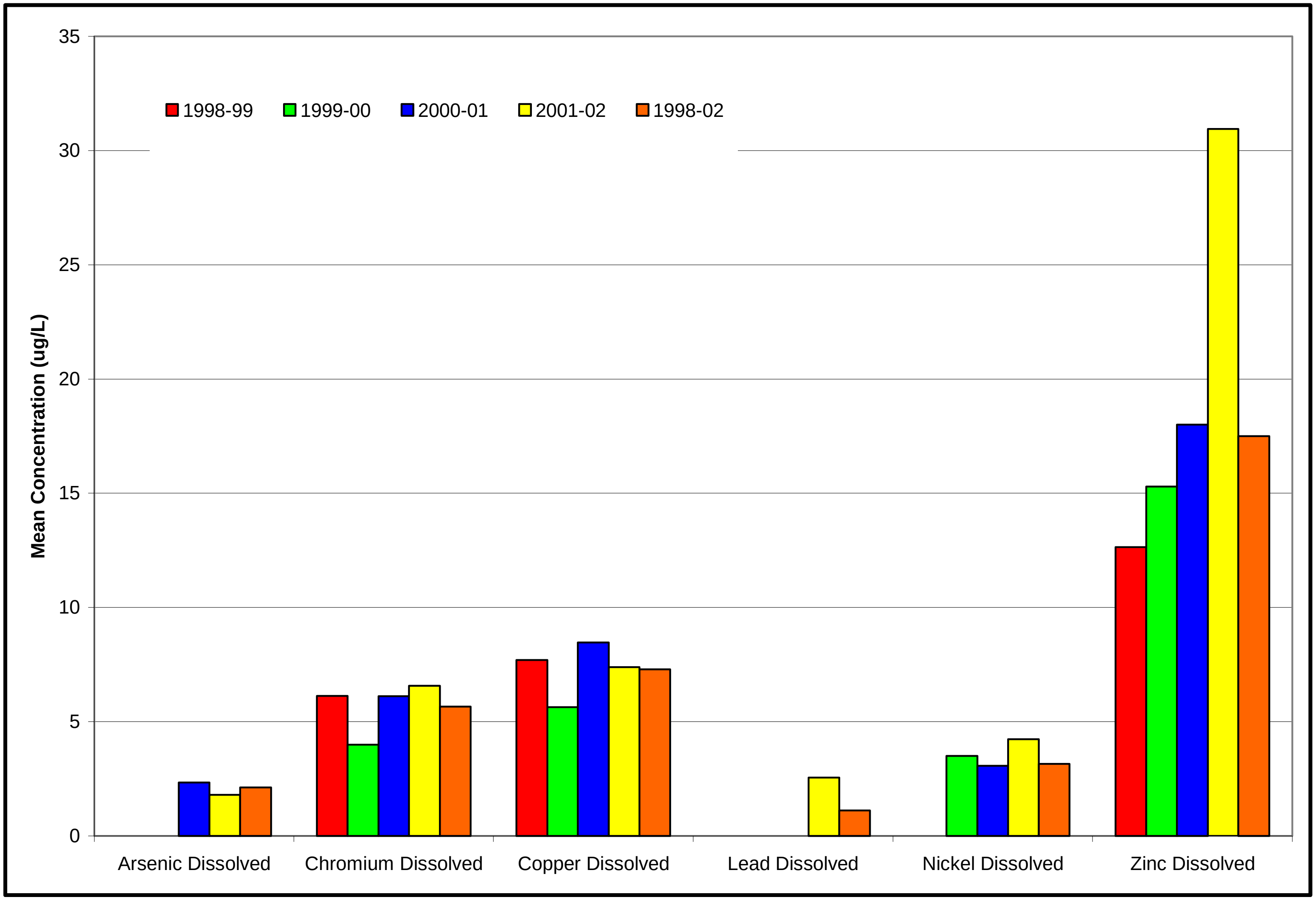


Figure 4-2
Comparison of Dissolved Metals Mean Concentration for
Construction Site Runoff Monitoring During Past Four Years

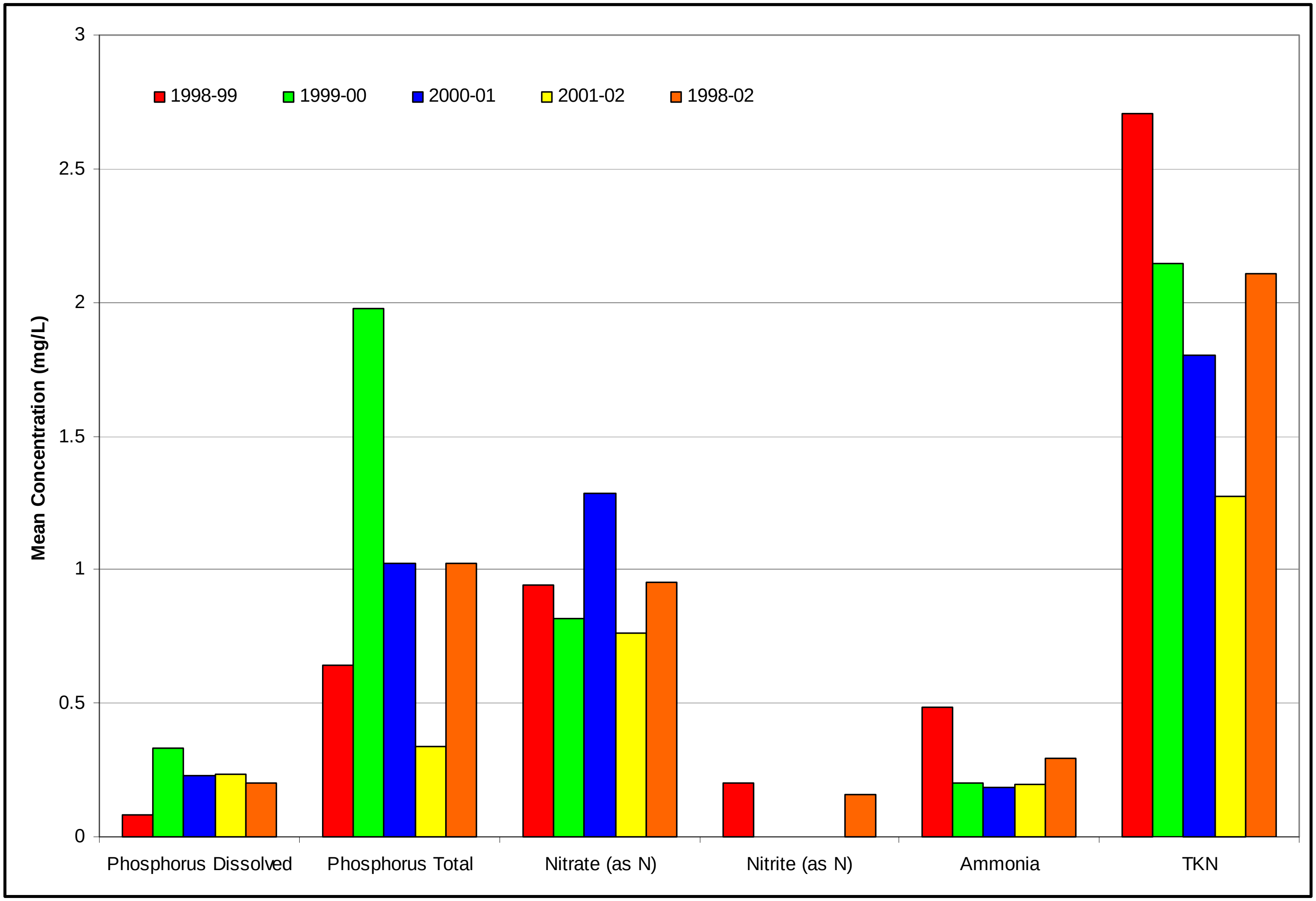


Figure 4-3
Comparison of Nutrients Mean Concentration for
Construction Site Runoff Monitoring During the Past Four Years

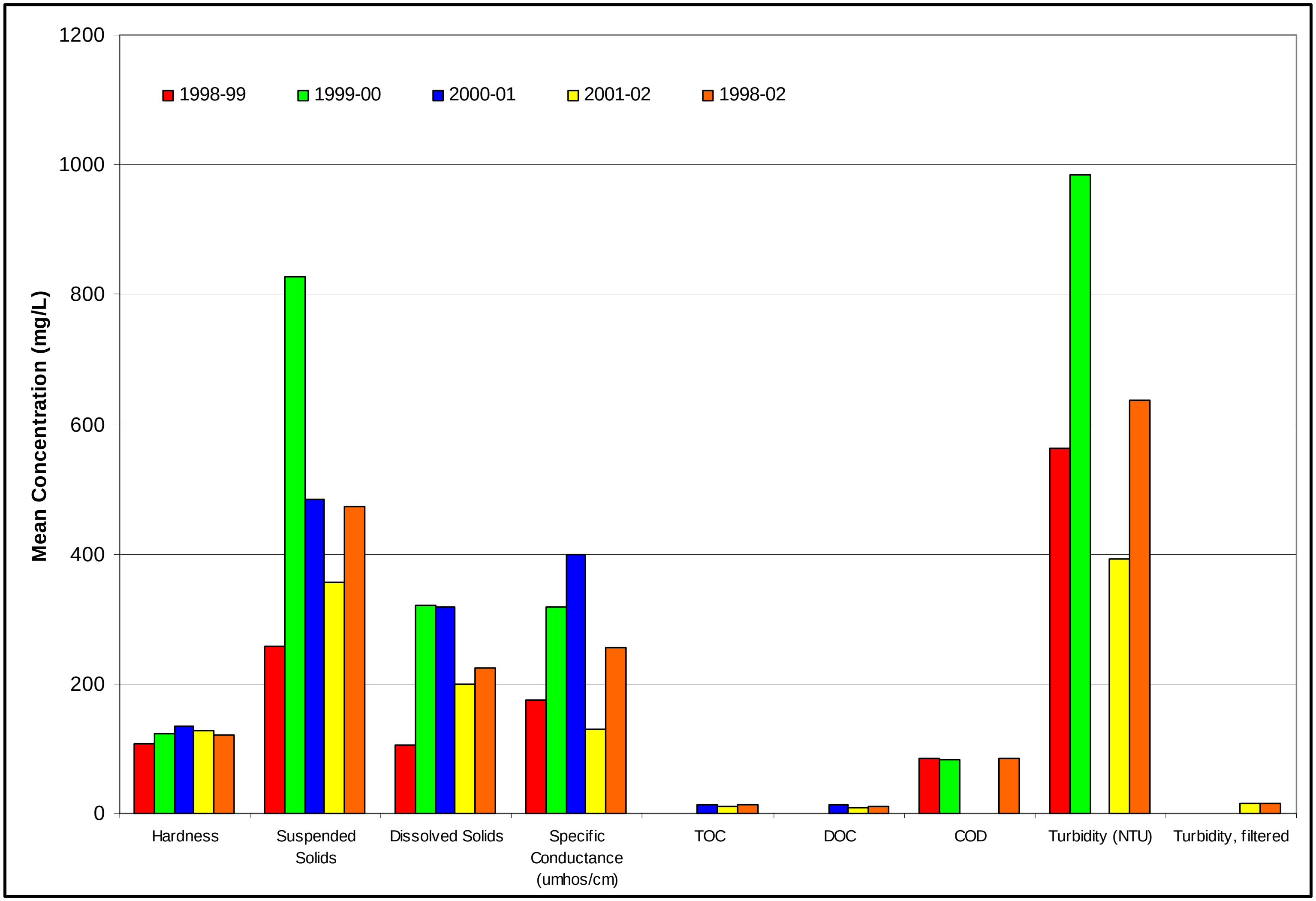


Figure 4-4
Comparison of Conventional Pollutants Mean Concentration for
Construction Site Runoff Monitoring During the Past Four Years

Nutrients

- With the exception of TKN, nutrient concentrations have been relatively consistent over the 4-year monitoring period, excluding one abnormally high Total Phosphorous concentration in the second year.

- Observed TKN concentrations have been lower each year over the 4-year study period.

- Total Phosphorous and TKN were lower in the fourth monitoring year compared to other monitoring years.

Conventional Pollutants

- Measured hardness was relatively consistent over the 4-year monitoring period.

- Total Suspended Solids concentrations were much higher during the second monitoring year compared to other monitoring years.

- Total Suspended Solids and Turbidity were closely correlated from year to year as expected since turbidity is primarily caused by suspended solids.

- Total and Dissolved Organic Carbon concentrations are low compared to Dissolved and Suspended Solids suggesting that Dissolved and Suspended Solids are primarily comprised of inorganic particulate matter.

Comparisons were not made for oil and grease, coliform, and pesticides since they were not monitored during the last two seasons.

Construction Site Analytical Results 1998-1999 Monitoring Season

Monitoring Site ID	Sample Event	Metals													
		Dissolved Cadmium ug/L	Total Cadmium ug/L	Dissolved Chromium ug/L	Total Chromium ug/L	Dissolved Copper ug/L	Total Copper ug/L	Dissolved Lead ug/L	Total Lead ug/L	Dissolved Nickel ug/L	Total Nickel ug/L	Dissolved Silver ug/L	Total Silver ug/L	Dissolved Zinc ug/L	Total Zinc ug/L
03-362404	1998-1	< 0.5	<0.5	<2	10.0	4.1	9.0	<0.5	10.0	<5	<5	<0.5	<0.5	9.1	32.0
03-362404	1998-2	<0.5	<0.5	<2	23.0	3.6	24.0	<0.5	65.0	<5	12.0	<0.5	<0.5	7.1	120.0
03-362404	1998-3	<0.5	<0.5	<2	11.0	8.1	5.6	<0.5	9.1	<5	<5	<0.5	<0.5	18.0	27.0
04-043934	1998-1	<0.5	0.6	4.4	34.0	5.6	37.0	<0.5	101.0	<5	27.0	<0.5	<0.5	<5	120.0
04-043934	1998-2	<0.5	1.4	6.2	74.0	4.3	110.0	<0.5	245.0	<5	89.0	<0.5	0.9	<5	340.0
04-043934	1998-3	<0.5	10.0	5.9	620.0	4.0	810.0	<0.5	2300.0	<5	790.0	<0.5	5.8	<5	3500.0
04-043934	1998-4	<0.5	0.5	13.0	39.0	11.0	40.0	<0.5	60.0	<5	27.0	<0.5	<0.5	<5	85.0
04-180154	1998-1	<0.5	<0.5	<2	7.7	8.6	15.0	0.5	7.3	<5	<5	<0.5	<0.5	20.0	45.0
04-180154	1998-2	<0.5	<0.5	<2	14.0	4.7	23.0	1.4	45.0	<5	13.0	<0.5	<0.5	33.0	185.0
04-180154	1998-3	<0.5	<0.5	<2	8.9	4.1	8.0	0.8	10.0	<5	<5	<0.5	<0.5	18.0	46.0
04-180154	1998-4	<0.5	<0.5	<2	17.0	7.1	9.7	15.0	23.0	<5	5.2	<0.5	<0.5	46.0	58.0
04-180154	1998-5	<0.5	<0.5	<2	11.0	3.7	14.0	0.6	22.0	<5	6.3	<0.5	<0.5	21.0	100.0
06-342254	1998-1	<0.5	<0.5	6.3	15.0	4.1	8.3	<0.5	1.5	<5	<5	<0.5	<0.5	<5	33.0
06-342254	1998-2	<0.5	<0.5	5.3	13.0	5.6	8.0	1.5	2.9	<5	<5	<0.5	<0.5	7.0	30.0
06-342254	1998-3	<0.5	<0.5	2.5	11.0	6.8	8.1	<0.5	1.7	<5	<5	<0.5	<0.5	17.0	36.0
06-342254	1998-4	<0.5	<0.5	2.4	7.2	7.3	11.0	<0.5	1.3	<5	<5	<0.5	<0.5	29.0	49.0
06-342254	1998-5	<0.5	<0.5	3.7	15.0	13.0	15.0	<0.5	1.6	6.1	7.4	<0.5	0.9	49.0	64.0
06-342264	1998-1	<0.5	<0.5	<2	64.0	<2	45.0	<0.5	30.0	<5	71.0	<0.5	<0.5	<5	120.0
06-342264	1998-2	<0.5	0.7	<2	63.0	<2	73.0	<0.5	58.0	<5	170.0	<0.5	0.5	<5	180.0
08-204304	1998-1	<0.5	<0.5	29.0	40.0	2.1	7.4	<0.5	2.5	<5	<5	<0.5	<0.5	<5	14.0
08-204304	1998-2	<0.5	<0.5	21.0	28.0	<2	3.8	<0.5	1.6	<5	<5	<0.5	<0.5	<5	6.9
08-204304	1998-3	<0.5	<0.5	16.0	37.0	<2	13.0	<0.5	8.1	<5	7.0	<0.5	<0.5	<5	44.0
08-204304	1998-4	<0.5	<0.5	13.0	36.0	3.3	9.6	<0.5	4.8	<5	5.4	<0.5	<0.5	<5	26.0
08-204304	1998-5	<0.5	<0.5	17.0	37.0	4.2	12.0	<0.5	7.2	<5	7.3	<0.5	<0.5	<5	43.0
08-204304	1998-6	<0.5	<0.5	6.1	19.0	<2	5.6	<0.5	2.5	<5	<5	<0.5	<0.5	<5	15.0
08-4632V4	1998-1	<0.5	0.7	3.3	19.0	25.0	45.0	2.6	53.0	5.6	11.0	<0.5	1.1	43.0	185.0
08-4632V4	1998-2	<0.5	<0.5	30.0	44.0	16.0	27.0	<0.5	21.0	<5	7.0	<0.5	<0.5	<5	97.0
08-4632V4	1998-3	<0.5	0.7	20.0	38.0	17.0	32.0	<0.5	32.0	<5	93.0	<0.5	<0.5	<5	150.0
08-4632V4	1998-4	<0.5	<0.5	15.0	26.0	19.0	29.0	<0.5	11.0	6.9	11.0	<0.5	<0.5	<5	84.0
08-4632V4	1998-5	<0.5	<0.5	6.2	18.0	13.0	26.0	<0.5	25.0	5.3	9.8	<0.5	<0.5	<5	75.0
11010744	1998-1														
11-183964	1998-1	<0.5	<0.5	<2	54.0	3.7	39.0	<0.5	27.0	<5	16.0	<0.5	<0.5	<5	120.0
11-183964	1998-2	<0.5	<0.5	<2	26.0	7.1	21.0	<0.5	12.0	<5	7.7	<0.5	<0.5	8.9	75.0
11-183964	1998-3	<0.5	1.2	<2	24.0	16.0	44.0	<0.5	27.0	<5	13.0	<0.5	<0.5	27.0	190.0
11-183964	1998-4	<0.5	0.6	<2	20.0	17.0	37.0	<0.5	20.0	<5	10.0	<0.5	<0.5	41.0	150.0
11-183964	1998-5	<0.5	<0.5	<2	25.0	16.0	39.0	<0.5	18.0	<5	13.0	<0.5	<0.5	22.0	120.0
11-183964	1998-6	<0.5	0.6	<2	39.0	8.9	40.0	<0.5	38.0	<5	16.0	<0.5	<0.5	9.2	160.0
11-183964	1998-7	<0.5	<0.5	<2	9.9	7.4	13.0	<0.5	6.2	5.3	7.7	<0.5	<0.5	<5	34.0
11-183965	1998-2														
12-012634	1998-1	<0.5	1.5	<2	65.0	5.9	70.0	<0.5	250.0	<5	40.0	<0.5	<0.5	<5	320.0
12-012634	1998-2	<0.5	0.7	<2	24.0	6.3	31.0	<0.5	47.0	<5	12.0	<0.5	<0.5	5.3	140.0
12-012634	1998-3	<0.5	<0.5	<2	15.0	6.2	16.0	0.6	18.0	<5	7.7	<0.5	<0.5	19.0	61.0
12-012634	1998-4	<0.5	<0.5	<2	16.0	6.9	19.0	<0.5	23.0	<5	8.7	<0.5	<0.5	6.1	76.0

Construction Site Analytical Results 1999-2000 Monitoring Season

Monitoring Site ID	Sample Date	Metals: Cadmium Dissolved ug/L	Cadmium Total ug/L	Chromium Dissolved ug/L	Chromium Total ug/L	Copper Dissolved ug/L	Copper Total ug/L	Lead Dissolved ug/L	Lead Total ug/L	Nickel Dissolved ug/L	Nickel Total ug/L	Silver Dissolved ug/L	Silver Total ug/L	Zinc Dissolved ug/L	Zinc Total ug/L
I-80 at Mace	1/24/2000	< 0.5	< 0.5	< 1	21	10	15	< 1	14	4	59	< 1	< 1	32	52
I-80 at Mace	2/10/2000	< 0.5	< 0.5	2	99.5	7	46	< 1	92	7	266	< 1	< 1	31	184
I-80 at Mace	2/13/2000	< 0.5	< 0.5	2	65	3	33	< 1	35	5	158	< 1	< 1	1	89
I-80 at Mace	2/16/2000	< 0.5	< 0.5	3	83	4	37	< 1	51	9	225	< 1	< 1	7	107
I-80 at Mace	2/20/2000	< 0.5	< 0.5	2	22	3	16	< 1	17	8	72	< 1	< 1	30	271
I-80 at Mace	2/27/2000	< 0.5	< 0.5	5	56	5	36	< 1	40	11	183	< 1	< 1	5	187
I-80 at Mace	4/17/2000	< 0.5	< 0.5	6	77	5	37	< 1	44	15	196	< 1	< 1	66	288
I-580/ I-680	1/24/2000	< 0.5	0.6	4	210	9	21	5	9	6	22	< 1	< 1	43	65
I-580/ I-680	2/27/2000	< 0.5	< 0.5	6	26	3	25	< 1	16	1	38	< 1	< 1	3	87
I-580/ I-680	3/7/2000	< 0.5	< 0.5	6	17	4	22	< 1	11	2	18	< 1	< 1	18	102
I-237/ I-880	3/2/2000	< 0.5	< 0.5	7	6.8	14	21	< 1	1	5	9	< 1	< 1	6	30
I-237/ I-880	3/7/2000	< 0.5	< 0.5	4	7	8	22	< 1	3	3	10	< 1	< 1	6	33
I-210/ I-15	1/25/2000	< 0.5	3.4	7	32	11	32	< 1	24	< 1	16	< 1	< 1	21	585
I-210/ I-15	2/12/2000	< 0.5	0.8	1	86	1	68	< 1	63	< 1	46	< 1	< 1	4	213
I-210/ I-15	2/20/2000	< 0.5	2	2	100	1	77	< 1	54	< 1	61	< 1	1	3	486
I-210/ I-15	2/23/2000	< 0.5	0.8	2	195	2	128	< 1	61	< 1	85	< 1	< 1	4	403
I-210/ I-15	2/27/2000	< 0.5	0.7	3	139	1	97	< 1	57	< 1	60	< 1	< 1	10	379
I-210/ I-15	3/5/2000	< 0.5	< 0.5	2	45	2	32	< 1	19	< 1	20	< 1	< 1	7	114
I-210/ I-15	3/8/2000	< 0.5	< 0.5	1	52	1	40	< 1	27	< 1	24	< 1	< 1	5	133
SR-55/ SR-22	2/12/2000	< 0.5	1.2	3	25	9	33	< 1	76	2	20	< 1	< 1	15	131
SR-55/ SR-22	2/20/2000	< 0.5	0.6	3	9	5	16	1	26	2	7	< 1	< 1	7	252
SR-55/ SR-22	2/23/2000	< 0.5	1.5	12	45	8	52	< 1	121	1	33	< 1	< 1	3	215
SR-55/ SR-22	3/5/2000	< 0.5	0.5	3	8	3	16	< 1	25	< 1	7	< 1	< 1	3	61
SR-55 at Walnut	1/25/2000	< 0.5	0.67	14	13	13	17	< 1	17	2	9	< 1	< 1	12	140
SR-55 at Walnut	2/20/2000	< 0.5	1.5	2	25	3	34	< 1	88	8	18	< 1	< 1	6	145
SR-55 at Walnut	2/23/2000	< 0.5	1.9	3	39	3	47	< 1	168	< 1	31	< 1	< 1	2	229
SR-55 at Walnut	2/27/2000	< 0.5	0.7	4	15	3	22	1	58	1	15	< 1	53	5	127
SR-55 at Walnut	3/5/2000	< 0.5	2	1	26	2	30	< 1	159	< 1	22	< 1	< 1	2	149
SR-55 at Walnut	3/8/2000	< 0.5	1.1	3	21	2	22	< 1	88	< 1	15	< 1	< 1	80	138
SR-55 at Walnut	4/17/2000	< 0.5	4.1	6	60	24	108	2	291	7	48	< 1	< 5	22	609

Notes:

1. If more than one coliform sample was collected during a storm event, then only the maximum value is reported.
2. Temperature, pH and specific conductance were measured in the field. Mean concentrations for each parameter for each monitoring site and date are shown.
3. <: Less than reporting limits

Construction Site Analytical Results 1999-00 Monitoring Season

Monitoring Site ID	Sample Date	Conventionals								Nutrients					
		Hardness mg/L	Suspended Solids mg/L	Dissolved Solids mg/L	pH pH Units	Specific Conductivity umhos/cm	Temp °C	Turbidity NTU	COD mg/L	Phosphorus Dissolved mg/L	Phosphorus Total mg/L	Nitrate (as N) mg/L	Nitrite (as N) mg/L	Ammonia mg/L	TKN mg/L
I-80 at Mace	1/24/2000	43	56	144	6.95	67.7	12	248	30	0.3	0.42	0.71	< 0.1	0.3	1.4
I-80 at Mace	2/10/2000	87	637	340	7.40	162.0	13	1200	49	0.5	0.79	0.66	< 0.1	0.2	2.8
I-80 at Mace	2/13/2000	37	482	233	7.70	66.7	14	688	31	< 0.1	0.12	0.63	< 0.1	0.2	1.7
I-80 at Mace	2/16/2000	74	552	370	7.84	197.0	13	1210	44	0.18	0.56	0.72	< 0.1	0.2	2.5
I-80 at Mace	2/20/2000	41	204	152	7.02	111.0	15	298	28	0.19	0.42	0.6	< 0.1	0.1	0.6
I-80 at Mace	2/27/2000	79	393	303	7.52	251.0	16	723	36	0.31	0.51	0.37	< 0.1	0.1	1.7
I-80 at Mace	4/17/2000	60	360	180	7.50	146.3	15	1100	230	0.45	0.86	1.8	< 0.1	0.2	2.2
I-580/ I-680	1/24/2000	84	160	213	9.20	20.5	14	354	31	0.38	0.49	0.87	< 0.1	< 0.1	1.4
I-580/ I-680	2/27/2000	60	469	200	7.45	227.8	13	561	34	0.27	0.49	0.61	< 0.1	0.1	1.1
I-580/ I-680	3/7/2000	107	187	230	7.28	376.0	13	221	49	0.26	7.1	0.78	< 0.1	0.2	0.8
I-237/ I-880	3/2/2000	594	16	1270	6.60	2240.0	15	17	54	< 0.1	0.11	0.23	< 0.1	< 0.1	< 0.5
I-237/ I-880	3/7/2000	660	43	717	6.85	2260.0	13	72	59	0.37	0.43	0.18	< 0.1	< 0.1	0.8
I-210/ I-15	1/25/2000	90	387	206	7.30	216.7	16	580	120	0.68	0.98	3.1	0.4	0.6	4.2
I-210/ I-15	2/12/2000	69	1430	436	8.48	89.2	14	2500	54	0.77	3.7	0.79	< 0.1	0.2	1.9
I-210/ I-15	2/20/2000	93	2770	305	7.25	63.8	13	765	65	0.17	1.2	0.47	< 0.1	0.2	2.5
I-210/ I-15	2/23/2000	96	2310	483	7.41	67.1	13	3390	88	0.11	110	0.49	< 0.1	0.2	2
I-210/ I-15	2/27/2000	112	3850	390	6.99	76.3	14	650	140	0.22	19	0.89	< 0.1	0.3	3.4
I-210/ I-15	3/5/2000	28	624	153	7.05	54.7	11	889	54	0.34	0.71	0.39	< 0.1	0.2	1.1
I-210/ I-15	3/8/2000	60	915	83	7.03	67.4	12	726	52	0.17	2.9	0.52	< 0.1	0.2	1.4
SR-55/ SR-22	2/12/2000	150	715	335	8.06	449.1	13	965	120	0.77	1.3	1.2	0.25	0.4	2.2
SR-55/ SR-22	2/20/2000	86	136	195	7.36	283.9	14	330	57	0.39	0.52	0.12	0.57	0.2	1.7
SR-55/ SR-22	2/23/2000	180	1250	252	8.16	296.1	15	1720	230	0.11	1.4	1.1	0.32	< 0.1	2
SR-55/ SR-22	3/5/2000	77	164	193	8.10	243.2	12	365	85	0.18	0.36	0.65	< 0.1	< 0.1	0.8
SR-55 at Walnut	1/25/2000	36	70	493	7.04	92.0	19	218	65	0.38	0.48	0.58	< 0.1	0.1	2.8
SR-55 at Walnut	2/20/2000	130	828	285				1260	49	0.22	1.3	0.23	< 0.1	0.2	1.7
SR-55 at Walnut	2/23/2000	97	1200	308	7.41	145.0	15	1730	62	0.31	1.1	0.4	< 0.1	< 0.1	2.2
SR-55 at Walnut	2/27/2000	81	286	247	7.25	186.0	16	629	44	0.28	0.7	0.18	< 0.1	< 0.1	1.1
SR-55 at Walnut	3/5/2000	130	1300	360	7.13	225.6	15	1870	93	0.3	2.9	0.89	< 0.1	0.2	2.2
SR-55 at Walnut	3/8/2000	110	495	147	7.04	273.0	12	868	36	0.33	2.4	0.51	< 0.1	0.2	1.4
SR-55 at Walnut	4/17/2000	180	2550	372	7.28	293.3	17	605	380	0.87	4.1	3.9	0.42	0.8	12.3

Construction Site Analytical Results 1999-00 Monitoring Season

Monitoring Site ID	Sample Date	OIL & Grease mg/L	Pesticides: Chlorpyrifos ug/L	Pesticides: Diazinon ug/L	Coliform: Total Coliform* MPN/100 ml	Coliform: Fecal Coliform* MPN/100 ml
I-80 at Mace	1/24/2000	< 1	< 0.03	0.09	23	
I-80 at Mace	2/10/2000	< 1	< 0.03	0.20	1600	1600
I-80 at Mace	2/13/2000	< 1	< 0.03	0.07	1600	540
I-80 at Mace	2/16/2000	1	0.04	0.04	1600	1600
I-80 at Mace	2/20/2000	< 1	< 0.03	0.05	1600	1600
I-80 at Mace	2/27/2000	< 1	< 0.03	< 0.03		
I-80 at Mace	4/17/2000	< 1	< 0.03	0.03		
I-580/ I-680	1/24/2000	< 1	< 0.03	0.06	16000	16000
I-580/ I-680	2/27/2000	< 1	< 0.03	0.04		
I-580/ I-680	3/7/2000	< 1	< 0.03	0.06	600	160
			0.00	0.00		
I-237/ I-880	3/2/2000	1	< 0.03	0.04	900	900
I-237/ I-880	3/7/2000	< 1	0.03	< 0.03	220	220
I-210/ I-15	1/25/2000	< 1	< 0.03	0.09	500	< 20
I-210/ I-15	2/12/2000	< 1	< 0.03	0.04	110	40
I-210/ I-15	2/20/2000	< 1	< 0.03	< 0.03	< 20	< 20
I-210/ I-15	2/23/2000	1	< 0.03	0.03	20	20
I-210/ I-15	2/27/2000	< 1	< 0.03	< 0.03	40	< 20
I-210/ I-15	3/5/2000	< 1	< 0.03	0.04	170	20
I-210/ I-15	3/8/2000	2	< 0.03	< 0.03	500	130
SR-55/ SR-22	2/12/2000	< 1	< 0.03	0.17	50000	80
SR-55/ SR-22	2/20/2000	2	< 0.03	0.09	140	70
SR-55/ SR-22	2/23/2000	< 1	< 0.03	0.10	8000	70
SR-55/ SR-22	3/5/2000	< 1	< 0.03	0.05	800	20
SR-55 at Walnut	1/25/2000	4			< 20	< 20
SR-55 at Walnut	2/20/2000	2	< 0.03	0.09	40	20
SR-55 at Walnut	2/23/2000	< 1	< 0.03	0.05	1300	800
SR-55 at Walnut	2/27/2000	< 1	< 0.03	0.06	500	300
SR-55 at Walnut	3/5/2000	< 1	< 0.03	0.04	3000	2300
SR-55 at Walnut	3/8/2000	1	< 0.03	0.03	13000	13000
SR-55 at Walnut	4/17/2000	< 1	0.04	0.14	50000	5000

Construction Site Analytical Results (2000-01 Monitoring Season)

Monitoring Site	Sample Start Date	Sample End Date	Arsenic (ug/L)		Cadmium (ug/L)		Chromium (ug/L)		Copper (ug/L)		Lead (ug/L)		Nickel (ug/L)		Zinc (ug/L)	
			Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total
SR4, Hercules	28-Oct-00	28-Oct-00	1.56	3.31	< 0.20	< 0.20	6.55	18.80	5.89	16.90	< 1	14.10	6.53	25.90	5.84	56.3
SR4, Hercules	10-Jan-01	10-Jan-01	1.13	3.02	< 0.20	0.41	2.17	9.60	3.52	18.50	< 1	24.40	5.19	6.25	5.65	54.1
SR4, Hercules	25-Jan-01	25-Jan-01	1.12	3.71	< 0.20	0.31	3.66	18.90	7.22	25.80	2.6	19.90	4.51	30.30	15.50	92.2
SR4, Hercules	10-Feb-01	11-Feb-01	1.06	2.28	< 0.20	< 0.20	2.47	11.60	5.42	9.59	< 1	5.54	4.46	14.10	6.54	58.7
SR4, Hercules	17-Feb-01	18-Feb-01	1.82	2.41	< 0.20	0.23	4.36	8.11	3.72	14.50	< 1	8.53	5.81	16.00	7.09	48.4
SR4, Hercules	3-Mar-01	4-Mar-01	1.67	2.14	< 0.20	0.25	1.73	10.30	5.52	10.00	< 1	6.67	5.24	12.50	16.50	48.6
I-580/I-680	28-Oct-00	28-Oct-00	1.76	6.43	< 0.20	0.26	4.45	42.90	3.61	40.80	< 1	18.40	2.95	49.80	13.00	93.2
I-580/I-680	10-Jan-01	10-Jan-01	4.15	6.68	< 0.20	0.43	9.58	56.10	5.64	37.90	< 1	25.00	2.13	67.90	13.20	114.0
I-580/I-680	25-Jan-01	25-Jan-01	2.36	7.81	< 0.20	0.53	5.27	61.50	29.80	46.50	< 1	36.10	2.18	72.70	7.15	159.0
I-237/I-880	28-Oct-00	28-Oct-00	4.07	3.95	< 0.20	< 0.20	10.10	16.40	11.10	28.60	< 1	30.00	4.52	15.20	34.10	69.7
I-237/I-880	10-Jan-01	10-Jan-01	1.82	3.07	< 0.20	0.52	4.05	31.50	6.80	33.00	< 1	24.70	2.66	53.30	69.80	98.9
I-237/I-880	25-Jan-01	25-Jan-01	0.79	2.92	< 0.20	0.60	1.79	32.50	6.18	31.30	< 1	30.70	< 2.00	50.20	38.80	209.0
I-15/I-210	8-Jan-01	8-Jan-01	< 0.50	23.10	< 0.20	< 1.00	6.43	100.00	8.52	165.00	< 1	49.20	< 2.00	55.40	11.20	441.0
I-15/I-210	10-Jan-01	11-Jan-01	1.65	2.51	< 0.20	< 1.00	4.66	83.10	1.82	63.80	< 1	41.70	< 2.00	36.10	5.00	248.0
I-15/I-210	12-Feb-01	12-Feb-01	0.81	1.64	< 0.20	0.22	1.98	34.40	2.74	27.50	< 1	17.90	< 2.00	15.20	< 5.00	114.0
I-15/I-210	24-Feb-01	24-Feb-01	1.63	1.27	< 0.20	< 0.20	6.05	14.10	2.51	9.70	< 1	5.98	2.00	4.50	6.97	38.5
I-15/I-210	6-Mar-01	6-Mar-01	1.59	2.55	< 0.20	0.41	2.89	17.60	7.67	16.60	1.3	10.40	2.00	7.08	56.70	57.2
I-15/I-210	7-Apr-01	7-Apr-01	< 0.50	3.98	< 0.20	0.34	3.26	36.60	10.40	34.10	< 1	21.60	< 2.00	17.90	19.50	136.0
SR-55/SR-22	27-Oct-00	27-Oct-00	2.82	6.78	< 0.20	< 1.00	5.08	22.20	17.60	41.40	3.53	51.50	4.20	17.70	15.40	245.0
SR-55/SR-22	10-Jan-01	11-Jan-01	2.03	2.90	< 0.20	< 1.00	5.31	21.30	10.30	27.30	< 1	26.50	< 2.00	43.60	9.93	104.0
SR-55/SR-22	12-Feb-01	12-Feb-01	1.91	5.87	< 0.20	0.94	4.32	26.20	7.69	30.80	< 1	78.00	< 2.00	19.00	12.10	125.0
SR-55/SR-22	24-Feb-01	24-Feb-01	2.29	4.58	< 0.20	< 0.20	17.60	24.70	13.10	13.00	< 1	6.36	2.33	3.49	10.10	43.6
SR-55/SR-22	6-Mar-01	6-Mar-01	5.15	6.20	0.59	0.62	31.30	38.60	25.70	34.20	36.5	41.30	8.82	13.70	49.70	67.7
SR-55/SR-22	7-Apr-01	7-Apr-01	2.04	3.01	< 0.20	0.32	9.15	15.00	7.66	15.70	< 1	22.20	2.07	7.11	10.70	96.6
SR-125 Maria Ct.	11-Jan-01	11-Jan-01	5.67	5.06	< 0.20	< 0.20	2.59	4.10	4.34	8.12	< 1	1.58	1.60	5.22	14.80	24.3
SR-125 Maria Ct.	26-Jan-01	26-Jan-01	3.12	4.90	< 0.20	< 0.20	6.24	10.60	6.12	12.60	< 1	7.03	2.52	7.76	15.20	58.4
SR-125 Maria Ct.	13-Feb-01	13-Feb-01	3.26	4.83	< 0.20	< 0.20	2.31	7.42	9.04	17.00	< 1	4.77	2.92	9.60	16.70	47.7
SR-125 Maria Ct.	6-Mar-01	6-Mar-01	7.19	8.07	< 0.20	0.45	6.09	22.30	7.48	18.20	< 1	12.40	2.61	8.05	14.50	102.0

		Construction Site Analytical Results (2000-2001 Monitoring Season)											
		Conventionals							Nutrients				
Monitoring Site	Sample Start Date	Hardness as CaCO3 mg/L	TSS mg/L	TDS mg/L	pH Units	Specific Conductance umhos/cm	TOC mg/L	DOC mg/L	Dissolved ortho-Phosphate mg/L	Total Phosphorus mg/L	NitrateNO3 (as N) mg/L	Ammonia NH3 (as N)	TKN mg/L
SR4, Hercules	28-Oct-00	124	313	307	7.18	372	19.0	19.0	0.03	0.29		0.1	2.0
SR4, Hercules	10-Jan-01	110	652	493	6.98	303	10.0	11.2	0.09	0.11	2.60	< 0.1	3.1
SR4, Hercules	25-Jan-01	80	712	407	7.43	262	8.1	7.9	0.16	0.18	0.50	< 0.1	1.9
SR4, Hercules	10-Feb-01	64	202	360	7.55	230	7.6	7.2	0.13	0.15	0.36	< 0.1	0.6
SR4, Hercules	17-Feb-01	76	240	283	7.22	272	10.2	10.1	0.15	0.22	0.44	< 0.1	0.7
SR4, Hercules	3-Mar-01	68	171	317	6.62	285	12.8	11.6	0.13	0.26	0.55	< 0.1	0.8
I-580/I-680	28-Oct-00	176	505	327	7.98	344	7.0	7.0	0.04	0.50		< 0.1	1.6
I-580/I-680	10-Jan-01	244	960	423	7.64	601	11.3	10.1	0.03	0.07	1.50	0.1	2.2
I-580/I-680	25-Jan-01	230	1,500	340	7.88	486	9.3	9.0	0.23	0.26	0.84	< 0.1	2.2
I-237/I-880	28-Oct-00	96	29	220	7.82	291	13.0	13.0	0.03	0.48		0.1	1.1
I-237/I-880	10-Jan-01	86	327	163	7.66	193	8.4	8.8	0.06	0.08	0.79	0.2	1.6
I-237/I-880	25-Jan-01	60	387	87	7.06	110	4.1	4.2	0.09	0.11	0.32	0.1	1.5
I-15/I-210	8-Jan-01	134	1,470	543	7.77	2,340	18.5	18.1	0.21	0.25	2.50	0.4	4.6
I-15/I-210	10-Jan-01	88	1,710	320	8.39	88	5.5	5.9	0.05	0.08	0.66	0.2	2.7
I-15/I-210	12-Feb-01	46	275	123	7.25	62	5.4	2.4	0.14	0.31	0.28	< 0.1	1.7
I-15/I-210	24-Feb-01	86	21	113	7.41	111	5.5	5.4	0.07	0.08	0.83	< 0.1	0.6
I-15/I-210	6-Mar-01	48	263	173	6.02	98	11.6	7.5	0.09	0.42	0.57	< 0.1	0.2
I-15/I-210	7-Apr-01	68	266	63	7.88	96	13.0	8.5	< 0.03	< 0.03	0.76	0.1	0.5
SR-55/SR-22	27-Oct-00	460	280	270	7.56	272	45.0	36.0	0.60	11.00	2.80	0.7	3.8
SR-55/SR-22	10-Jan-01	106	183	227	7.37	255	19.4	19.1	0.08	0.14	2.80	0.6	2.2
SR-55/SR-22	12-Feb-01	122	937	200	9.06	190	6.8	7.0	0.12	0.32	1.10	0.2	2.5
SR-55/SR-22	24-Feb-01	136	626	243	9.70	350	16.9	16.0	0.03	0.12	1.80	0.2	0.5
SR-55/SR-22	6-Mar-01	130	422	437	9.70	482	19.8	17.7	< 0.03	0.54	2.20	0.2	0.6
SR-55/SR-22	7-Apr-01	152	40	270	7.95	412	14.5	11.5	0.12	0.17	1.70	0.1	0.5
SR-125 Maria Ct.	11-Jan-01	170	48	490	7.07	639	13.2	11.7	0.48	0.55	2.30	0.2	3.8
SR-125 Maria Ct.	26-Jan-01	240	258	570	7.45	823	18.2	16.4	0.51	0.52	1.50	0.4	4.1
SR-125 Maria Ct.	13-Feb-01	204	175	490	7.30	709	32.7	26.8	1.08	1.44	0.68	0.9	1.4
SR-125 Maria Ct.	6-Mar-01	194	619	687	7.35	492	26.5	19.2	1.60	10.00	1.80	< 0.1	1.5

Construction Site Analytical Results (2001-2002 Monitoring Season)																
Monitoring Site	Event Start	Event End	Arsenic (As)		Cadmium (Cd)		Chromium (Cr)		Copper (Cu)		Lead (Pb)		Nickel (Ni)		Zinc (Zn)	
			Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total
			ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L	
I-50/ Sunrise	12/1/2001	12/1/2001	1.45	7.23	<0.2	0.259	10.8	28.9	15.8	29	12.7	46.3	8.65	24.7	50.6	68.4
I-50/ Sunrise	12/14/2001	12/14/2001	2.19	6.85	<0.2	<1	2.67	40.8	4.41	48.6	3.52	84.9	3.72	41	8.15	201
I-50/ Sunrise	12/20/2001	12/20/2001	1.32	4.34	<0.2	1.04	3.77	28.1	4.28	30.1	2.71	54.4	4.88	29.4	9.73	74.6
I-50/ Sunrise	12/28/2001	12/28/2001	1.96	3.37	<0.2	<0.2	6.86	24.2	6.51	29.1	4.19	43.8	8.6	23.7	25.7	74.3
I-50/ Sunrise	1/26/2002	1/26/2002	1.14	4.17	<0.2	<0.2	2.76	18.1	5.45	29	<1	29.8	3.83	19.4	17.9	134
I-50/ Sunrise	2/16/2002	2/16/2002	<0.5	4.44	<0.2	<0.2	2.64	20.3	5.4	23.7	<1	34.3	<2	19.6	39.3	60.3
I-50/ Sunrise	3/6/2002	3/6/2002	1.35	12.8	<0.2	1.22	3.89	44.2	5.66	49.2	4.49	77.7	5.54	41.6	29.7	111
I-50/ Sunrise	3/10/2002	3/10/2002	1.13	3.48	<0.2	0.296	3.85	19.3	10.9	23.6	5.84	46.9	4.6	18.3	31.1	114
SR4	11/28/2001	11/29/2001	1.7	1.69	<0.2	<0.2	14.9	14.8	4.26	9.11	<1	1.21	<2	3.99	11.7	38.6
SR4	12/1/2001	12/1/2001	1.91	2.19	0.488	0.633	31.5	31.6	5.08	7.44	1.09	2.07	3.17	5.02	17.4	37.2
SR4	12/13/2001	12/14/2001	1.43	1.57	<0.2	0.408	4.99	5.87	3.6	8.04	<1	7.61	2.77	6.33	12.7	72.1
SR4	12/19/2001	12/20/2001	<0.5	0.781	<0.2	<0.2	4.42	4.43	5.01	7.58	<1	1.88	2.5	6.25	18.8	23.5
SR4	12/22/2001	12/22/2001	1.8	1.56	<0.2	<0.2	4.89	4.32	3.88	6.49	<1	1.39	3.5	4.91	9.8	29.1
SR4	12/28/2001	12/28/2001	1.74	1.83	<0.2	<0.2	5.67	6.23	6.02	8.16	<1	2.1	4.05	5.85	16.3	27.3
SR4	2/16/2002	2/16/2002	<0.5	0.664	<0.2	<0.2	1.88	2.06	4.84	5.88	<1	1.42	<2	2.87	17.4	28.8
SR4	3/9/2002	3/10/2002	<0.5	0.501	<0.2	<0.2	1.45	3.01	2.78	5.48	<1	2.09	<2	4.05	28	31.4
I-210/ Milliken	3/17/2002	3/17/2002	<0.5	2.25	<0.2	1.01	1.83	59.1	2.71	71.6	<1	64.4	<2	34.6	11.7	248
405/ 73	12/20/2001	12/21/2001	4.92	9.29	0.241	1.54	10.9	44.8	27.9	60.1	6.52	56.6	10.2	33.8	209	212
405/ 73	11/29/2001	11/29/2001	7.08	9.37	<0.2	0.628	5.18	15.7	15.7	34.1	1.89	50.2	6.18	14.4	23.1	144

Notes:
(1) Turbidity of sample
and filtrate were measured

Construction Site Analytical Results (2001-02 Monitoring Season) (cont.)

Monitoring Site	Event Start	Conventionals									Nutrients				
		Hardness as CaCO3	Total Suspended Solids	Total Dissolved Solids	pH	Specific Conductance	TOC	DOC	Turbidity	Turbidity Filtered (1)	Dissolved ortho-Phosphate	Total Phosphorous (K)	Nitrate (as N)	Ammonia	TKN
		mg/L	mg/L	mg/L	pH Units	umhos/cm	mg/L	mg/L	NTU	NTU	mg/L	mg/L	mg/L	mg/L	mg/L
I-50/ Sunrise	12/1/2001	60	310	220	6.82	130	9.9	4.2	730	12	0.099	0.12	2.4	0.17	1.3
I-50/ Sunrise	12/14/2001	34	120	480	6.91	72	4.5	4.8	940	36	0.26	0.47	0.98	0.28	1.4
I-50/ Sunrise	12/20/2001	46	300	280	6.79	97	6.8	5.6	710	27	0.17	0.27	1.5	<0.1	<0.1
I-50/ Sunrise	12/28/2001	36	100	270	6.87	60	3.2	3.8	630	31	0.21	0.25	0.38	<0.1	1.3
I-50/ Sunrise	1/26/2002	44	200	150	6.85	85	8	5.2	300	18	0.09	0.37	1.3	0.22	1.7
I-50/ Sunrise	2/16/2002	28	160	240	6.94	63	9.1	7.2	590	0.23	0.17	0.43	1.1	0.45	1.4
I-50/ Sunrise	3/6/2002	38	460	160	6.35	53	6.2	5.4	740	12	0.089	0.099	0.51	0.34	0.7
I-50/ Sunrise	3/10/2002	32	200	170	6.68	49	5.3	6.4	560	21	0.14	0.15	0.4	<0.1	1.1
SR4	11/28/2001	40	17	120	6.95	190	9.6	8.8	32	1.1	0.5	0.55	0.27	<0.1	0.98
SR4	12/1/2001	36	37	120	6.45	130	7.3	5.4	44	3.6	0.54	0.59	0.25	<0.1	0.98
SR4	12/13/2001	42	36	100	7.03	140	7	5.5	49	2	0.36	0.55	0.2	<0.1	0.7
SR4	12/19/2001	28	47	100	6.66	120	8.6	6.2	57	3.9	0.17	0.3	0.17	<0.1	<0.1
SR4	12/22/2001	64	17	180	6.69	250	8.5	7	30	1.7	0.5	0.6	0.16	<0.1	<0.1
SR4	12/28/2001	44	20	160	6.87	200	7.4	6.1	43	1.9	0.42	0.54	0.2	<0.1	0.84
SR4	2/16/2002	12	14	53	7.02	63	8.7	6.6	25	0.43	0.098	0.13	0.27	<0.1	<0.1
SR4	3/9/2002	18	48	47	6.7	48	6.1	5.4	52	2.5	0.12	0.15	0.12	<0.1	0.56
I-210/ Milliken	3/17/2002	1600	2500	430	7.89	160	12	7.9	510	140	0.16	0.46	1.1	<0.1	2.4
405/ 73	12/20/2001	110	770	300	8.14	300	42	40	910	1.8	0.18	0.2	1.9	0.62	3.2
405/ 73	11/29/2001	120	1400	230	7.83	270	40	30	510	1.1	0.2	0.21	1.3	1	4.3

Notes:
(1) Turbidity of sample
and filtrate were measured

Section 5
Data Evaluation

Using the data collected over the past four years, a baseline of construction site storm water runoff water quality data has been established. Additional observations can be made about the data by drawing comparisons within the data set and with other data sources. Constituent concentrations can also be plotted against each other to observe if any relationships occur between constituents.

5.1 Construction Site Data

The data collected over the past four years can be categorized in several ways to draw comparisons. Two such comparisons can be made between construction site types and construction site location. In the first series of comparisons, storm water quality from construction of new facilities is compared to storm water quality from the modification of existing facilities. The second comparison uses geographic location to categorize the construction sites.

In both of these comparisons, box plots have been produced to visually portray the data. A statistical comparison test was applied to determine whether the comparisons indicate statistically different water quality based on the distribution of the data.

The first step in conducting the statistical comparisons is to establish the hypothesis to be tested. For this study, the hypothesis tested was that the means of the two groups were the same, or:

$$\mu_{New} = \mu_{Existing}$$

$$\mu_{NorthCA} = \mu_{SouthCA}$$

$$\mu_{Construction} = \mu_{Highway}$$

The statistical comparison tests conducted in this study provide a way of evaluating whether the differences observed between the mean estimates represents an actual difference between the true means. The evaluation is based on calculation of the probability that the two true means are different given the amount of difference in the estimated (sample) means.

The second step was to establish a threshold probability for the test. This threshold is known as the level of statistical significance (α). The level of statistical significance provides the false positive probability, which is the probability of concluding, based on the test results, that a significant difference exists when in reality it does not exist. For purposes of the tests conducted in this study, $\alpha = 0.1$ has been established or 10% probability of generating a false positive result.

An unpaired or two sample t-test was conducted on runoff water quality data from each set of data to be compared. A t-test is a method of determining whether the means of two population distributions are the same statistically. When the t-test is conducted, a probability is calculated that can be compared with α. This probability (known as a p-value) represents the probability that the estimated event mean concentration (EMC) values could be as different as they are while at the same time the true EMC means are the same. Therefore, in order to discern a statistically significant difference, resulting p-values must be less than 0.1 (i.e., less than 10 percent probability that the mean estimates could be as different as they are and still have the same true means).

Comparisons of the construction site runoff between the four years were conducted using analysis of variance (ANOVA). The ANOVA test evaluates whether there is a statistically significant difference between the means of the data sets, i.e., the null hypothesis (H_0) that the populations from which the four data sets have been drawn have the same mean is tested against the alternative (H_A) that at least one of the populations have a different mean from at least one other population. The ANOVA test is an extension of the t-test for comparing more than two data sets simultaneously. If the ANOVA test determines that there is a difference between at least two of the means, then contrast (or post-hoc) tests are conducted to identify which means are statistically different.

5.1.1 New Construction vs. Modification to Existing Facilities

An obvious point of differentiation involves comparing new roadway construction to modification to existing facilities. One might expect new roadway construction, where no construction had occurred in the past, to disturb more soil and impact larger drainage areas resulting in higher TSS and turbidity values. Conversely, where soils and pavements were disturbed at older sites, one might expect to observe higher loads of constituents that result from years of road use, such as Copper, Zinc, Lead, and Nickel. Comparison of data from the five categories is shown in the box plots in Figures 5-1 though 5-5. Box plots are a visual tool that are effective in providing an understanding of where the mean and median fall within the 75th and 25th percentile of data (top and bottom of the box), and the breadth of the data spread (tail on the top and bottom of the box). Table 5-1 lists the p-value calculated using the statistical comparison test to determine significant difference. Based on the statistical comparison test, only Dissolved Copper, Total Coliform, Dissolved Lead, Dissolved Nickel and Dissolved Zinc show a significant difference between new construction and modification to existing facilities. The concentrations of each of these constituents were lower at the new construction sites. The mean concentration difference between those constituents showing a significant difference is shown in Table 5-2.

Table 5-1

Statistical Comparison Test on New Construction vs Existing Modification

Constituent	p-value	Significant Difference	Constituent	p-value	Significant Difference
Dissolved Arsenic	0.9696	No	Dissolved Lead	0.0846	Yes
Total Arsenic	0.8804	No	Total Lead	0.3344	No
Dissolved Cadmium	N/A	N/A	Dissolved Nickel	0.0221	Yes
Total Cadmium	0.3258	No	Total Nickel	0.3203	No
Dissolved Chromium	0.9486	No	Dissolved Silver	N/A	N/A
Total Chromium	0.8881	No	Total Silver	N/A	N/A
Dissolved Copper	0.0006	Yes	Dissolved Zinc	0.0735	Yes
Total Copper	0.7188	No	Total Zinc	0.6580	No
Dissolved ortho-Phosphate	0.6191	No	TDS	0.5174	No
Total Phosphorus	0.1663	No	TSS	0.2025	No
Nitrate NO3 (as N)	0.8479	No	Turbidity	0.8874	No
Nitrite NO2 (as N)	0.9254	No	Hardness as CaCO3	0.2773	No
AmmoniaNH3 (as N)	0.4253	No	pH	0.4051	No
TKN	0.3861	No	Specific Conductance	0.9382	No
			TOC	0.8858	No
Oil and Grease	0.8740	No	COD	0.5947	No
Diazinon	0.3413	No	DOC	0.6698	No
Total Coliform	0.0750	Yes			
Fecal Coliform	0.5267	No			

(N/A) Too many data points below detection limit. Unable to analyze using Caltrans statistical tool.

Table 5-2

Concentration Difference of Constituents Showing Significant Difference Between New Construction vs Existing Modifications

Constituent	Units	New Construction	Other Construction	Difference (%)
Dissolved Copper	µg/L	4.55	8.48	46
Dissolved Nickel	µg/L	2.34	3.53	34
Dissolved Lead	µg/L	<0.5*	1.49	66
Dissolved Zinc	µg/L	11.22	20.27	45
Total Coliform	MPN/100 mL	2576.06	46308.27	94

* No statistical mean, too many values below non detect.

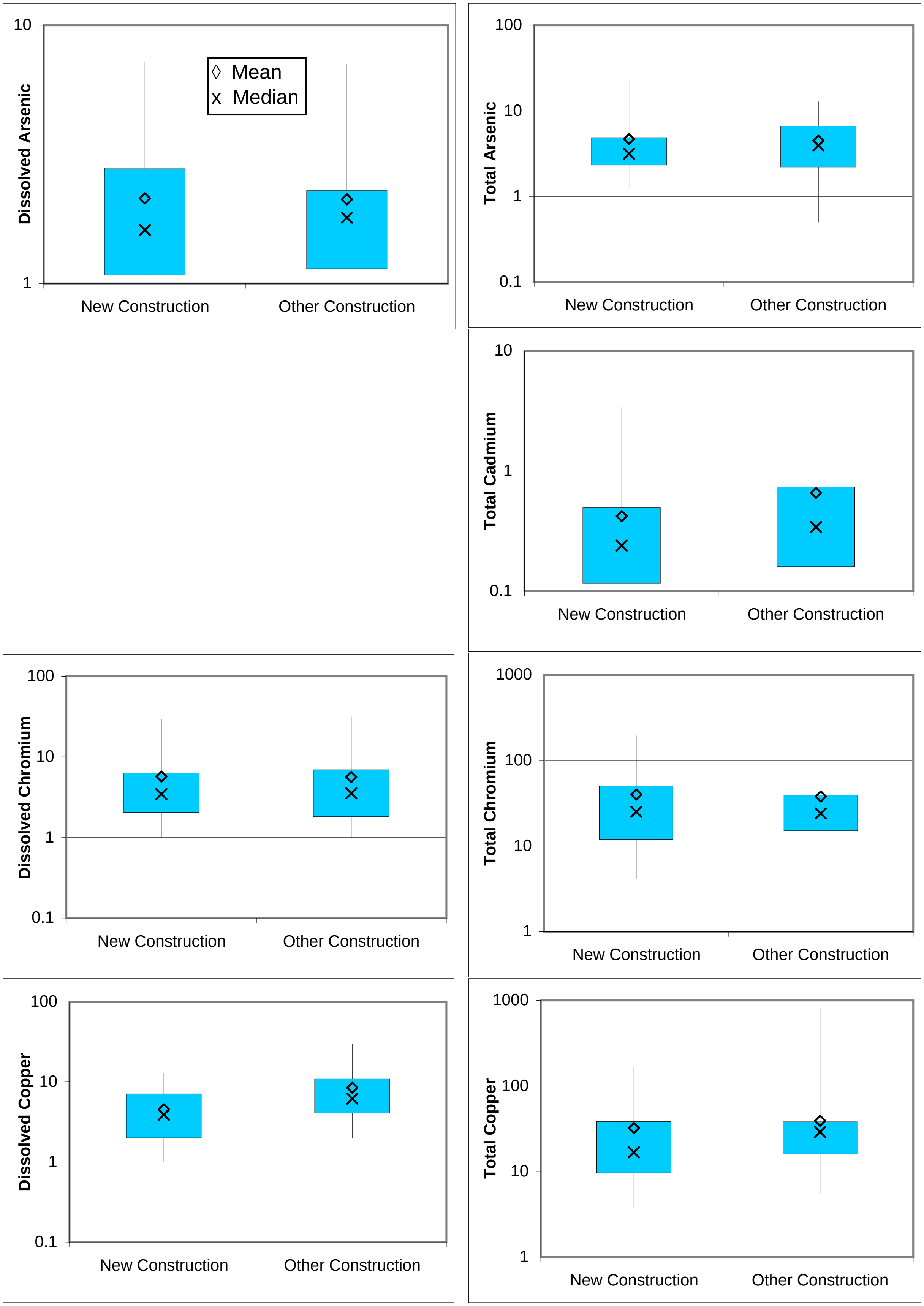


Figure 5-1
New vs Other Construction 1998-2002
Metals (ug/L)

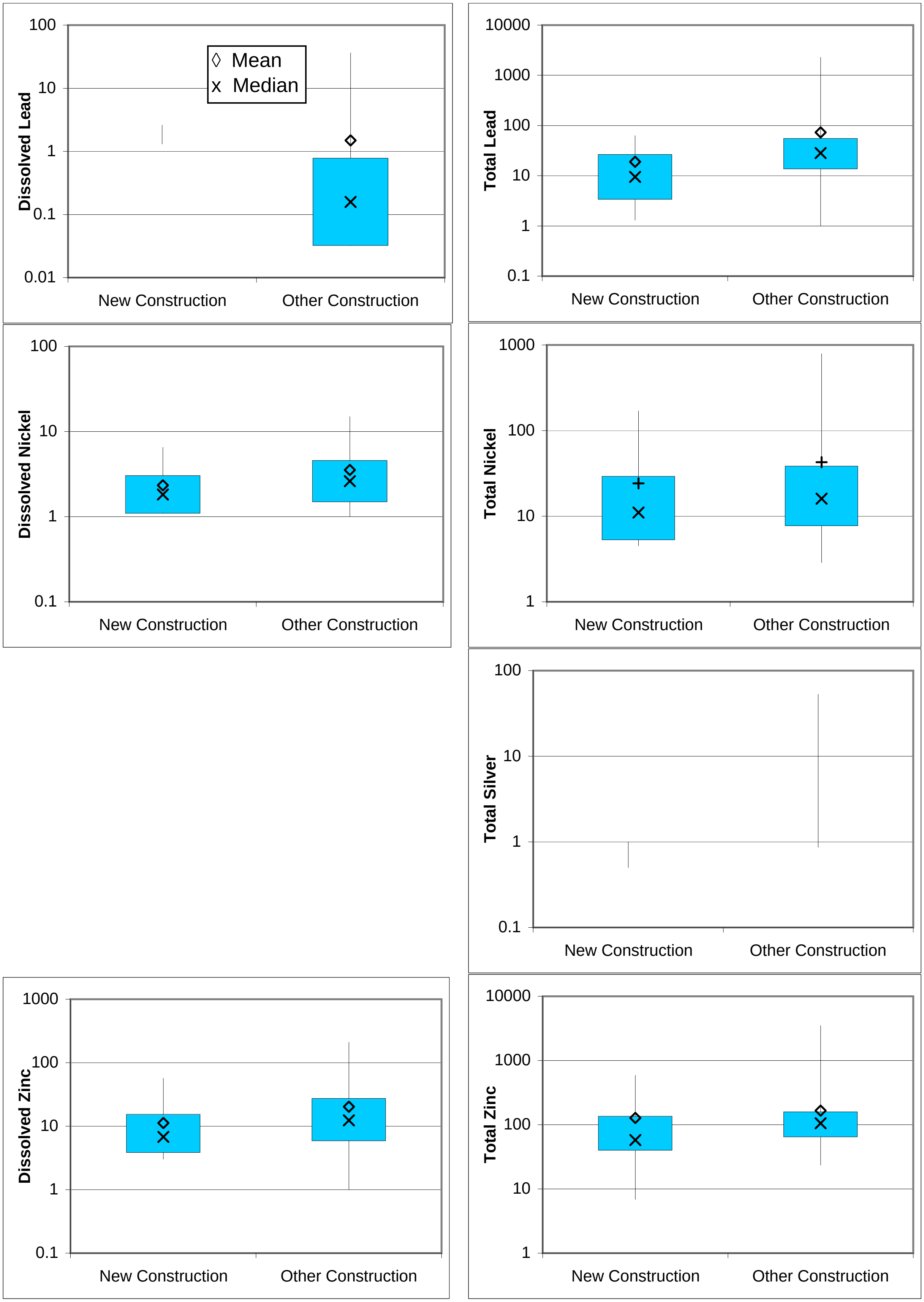


Figure 5-2
New vs Other Construction 1998-2002
Metals (ug/L)

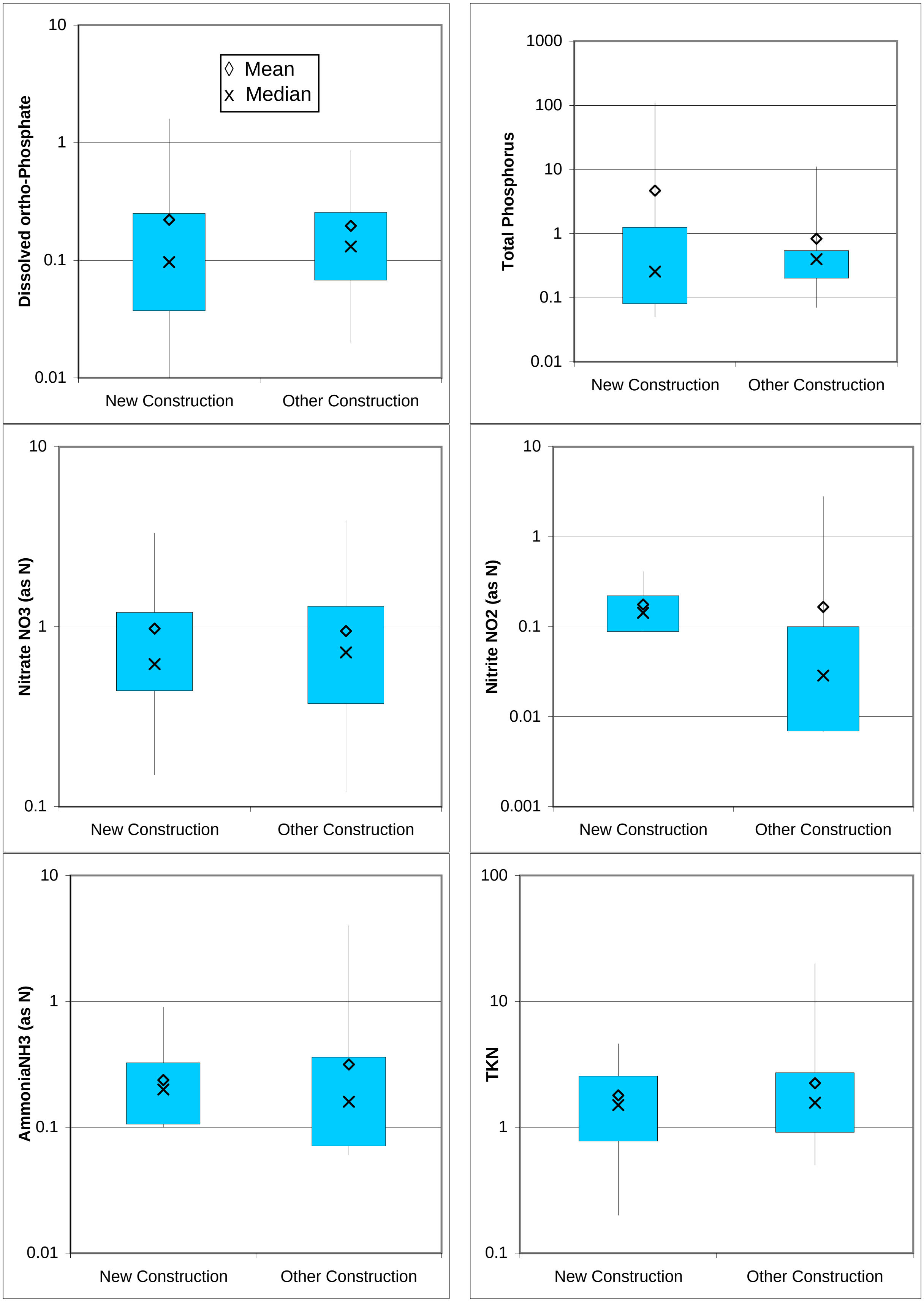
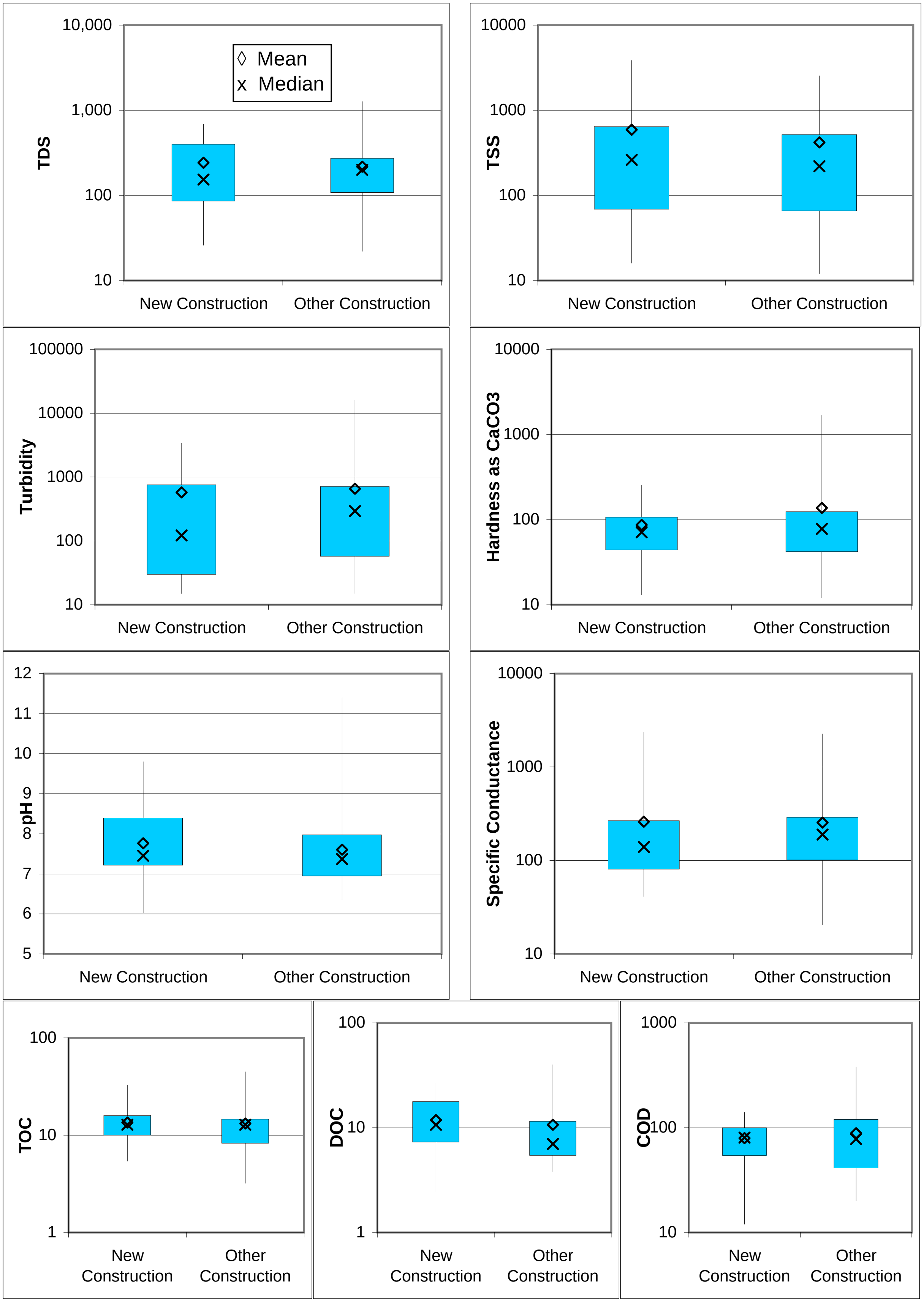
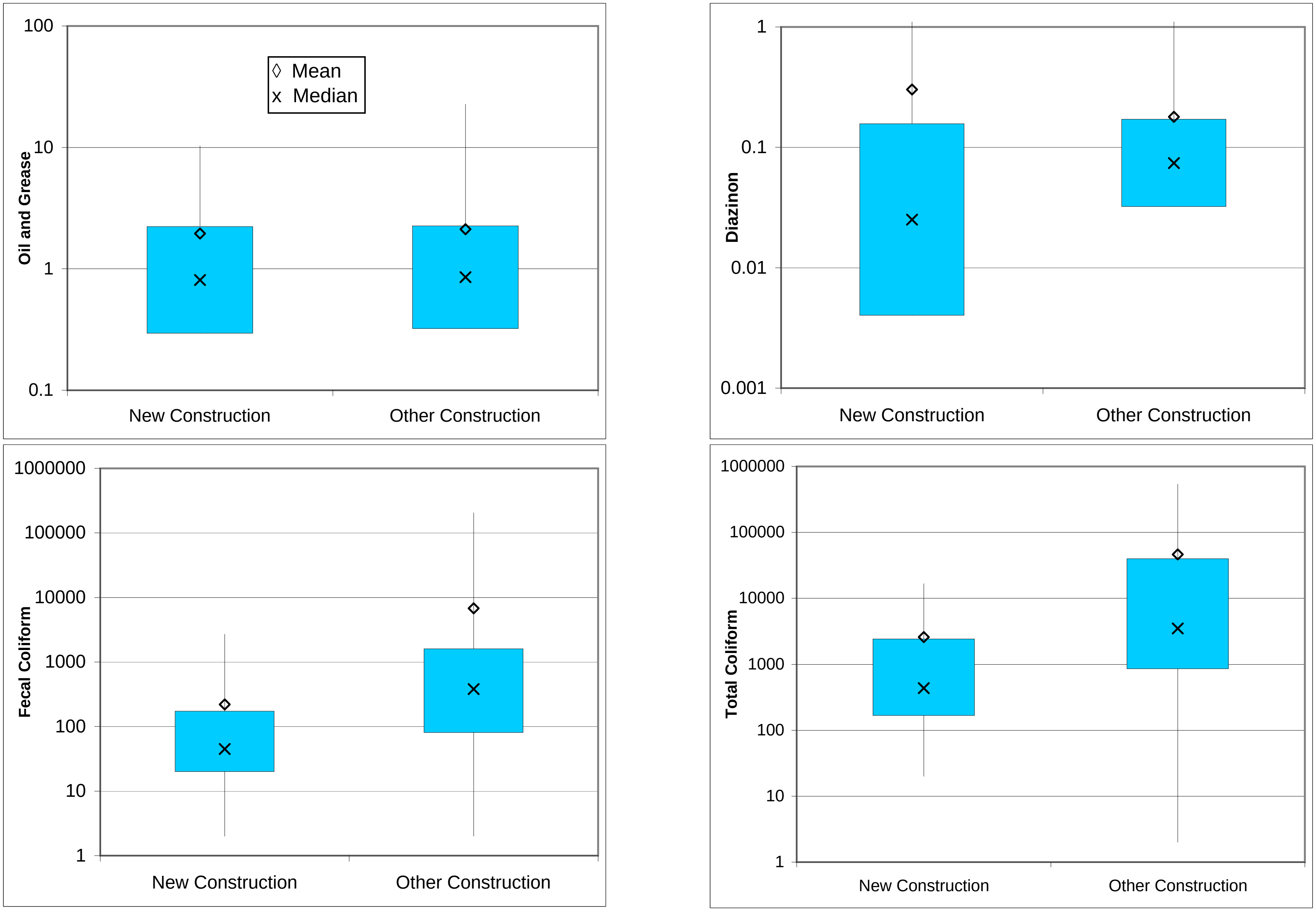


Figure 5-3
New vs Other Construction 1998-2002
Nutrients (ug/L)



Turbidity - NTU
pH - pH units
Specific Conductance - umhos/cm

Figure 5-4
New vs Other Construction 1998-2002
Conventionals (ug/L)



Oil and Greese - mg/L
Diazinon - ug/L
Coliform - MPN/100mL

Figure 5-5
New vs Other Construction 1998-2002
Others

5.1.2 Northern Sites vs. Southern Sites

The comparison of the data for these two distinct climatic sections of the state is based on the aggregate information collected over the last four monitoring seasons. This comparison is presented in the box plots in Figure 5-6 through 5-10. Statistical significance test results are presented in Table 5-3.

Statistically significant differences exist for Dissolved Arsenic, Dissolved Chromium, Nitrate, Nitrite, Ammonia, TKN, Dissolved Lead, Dissolved Nickel, Total Nickel, TSS, TOC, and DOC. As shown in the box plots, many constituents with significant differences occur with higher concentrations in southern California. Though more evident in the dissolved metals and nutrients concentrations, this situation is also observed in the other constituents. This may be due to the comparatively low rainfall amounts in southern California over the past four years. Assuming equal site conditions, less rainfall could result in less runoff which may concentrate the constituents leaving the site.

Table 5-3

Statistical Comparison Test on Northern vs. Southern California Construction

Constituent	p-value	Significant Difference	Constituent	p-value	Significant Difference
Dissolved Arsenic	0.0103	Yes	Dissolved Lead	0.0017	Yes
Total Arsenic	0.6312	No	Total Lead	0.6497	No
Dissolved Cadmium	N/A	N/A	Dissolved Nickel	0.0002	Yes
Total Cadmium	0.3093	No	Total Nickel	0.0466	Yes
Dissolved Chromium	0.0831	Yes	Dissolved Silver	N/A	N/A
Total Chromium	0.7942	No	Total Silver	N/A	N/A
Dissolved Copper	0.0808	Yes	Dissolved Zinc	0.4778	No
Total Copper	0.9068	No	Total Zinc	0.9733	No
Dissolved ortho-Phosphate	0.1212	No	TDS	0.3169	No
Total Phosphorus	0.3318	No	TSS	0.0089	Yes
Nitrate NO3 (as N)	0.0000	Yes	Turbidity	0.8794	No
Nitrite NO2 (as N)	0.0092	Yes	Hardness as CaCO3	0.7156	No
AmmoniaNH3 (as N)	0.0157	Yes	pH	0.0003	Yes
TKN	0.0600	Yes	Specific Conductance	0.6412	No
			TOC	0.0055	Yes
Oil and Grease	0.3210	No	COD	0.6390	No
Diazinon	0.1159	No	DOC	0.0002	Yes
Total Coliform	0.5639	No			
Fecal Coliform	0.4556	No			

(N/A) Too many data points below detection limit. Unable to analyze using Caltrans statistical tool.

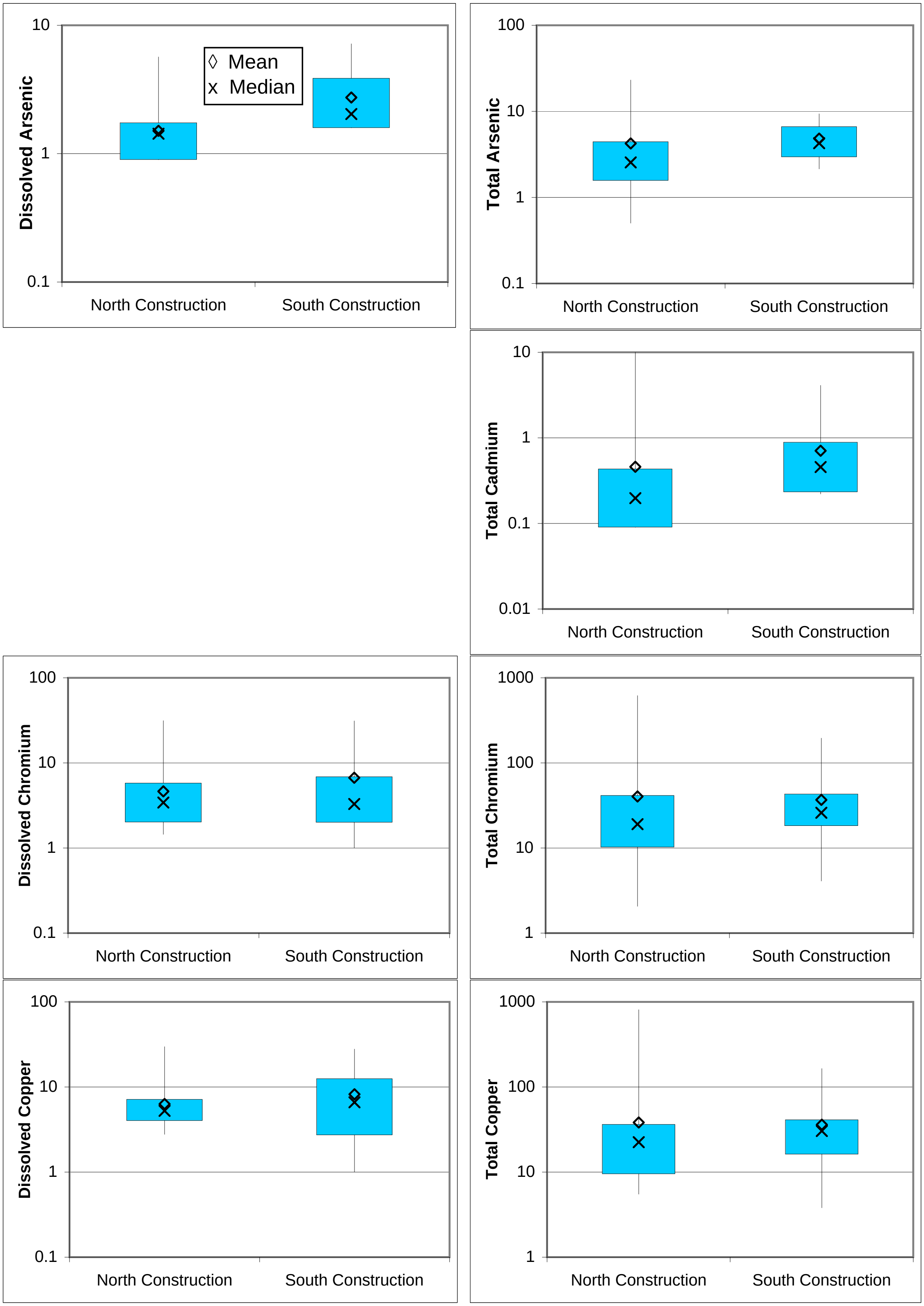


Figure 5-6
North vs South Construction 1998-2002
Metals (ug/L)

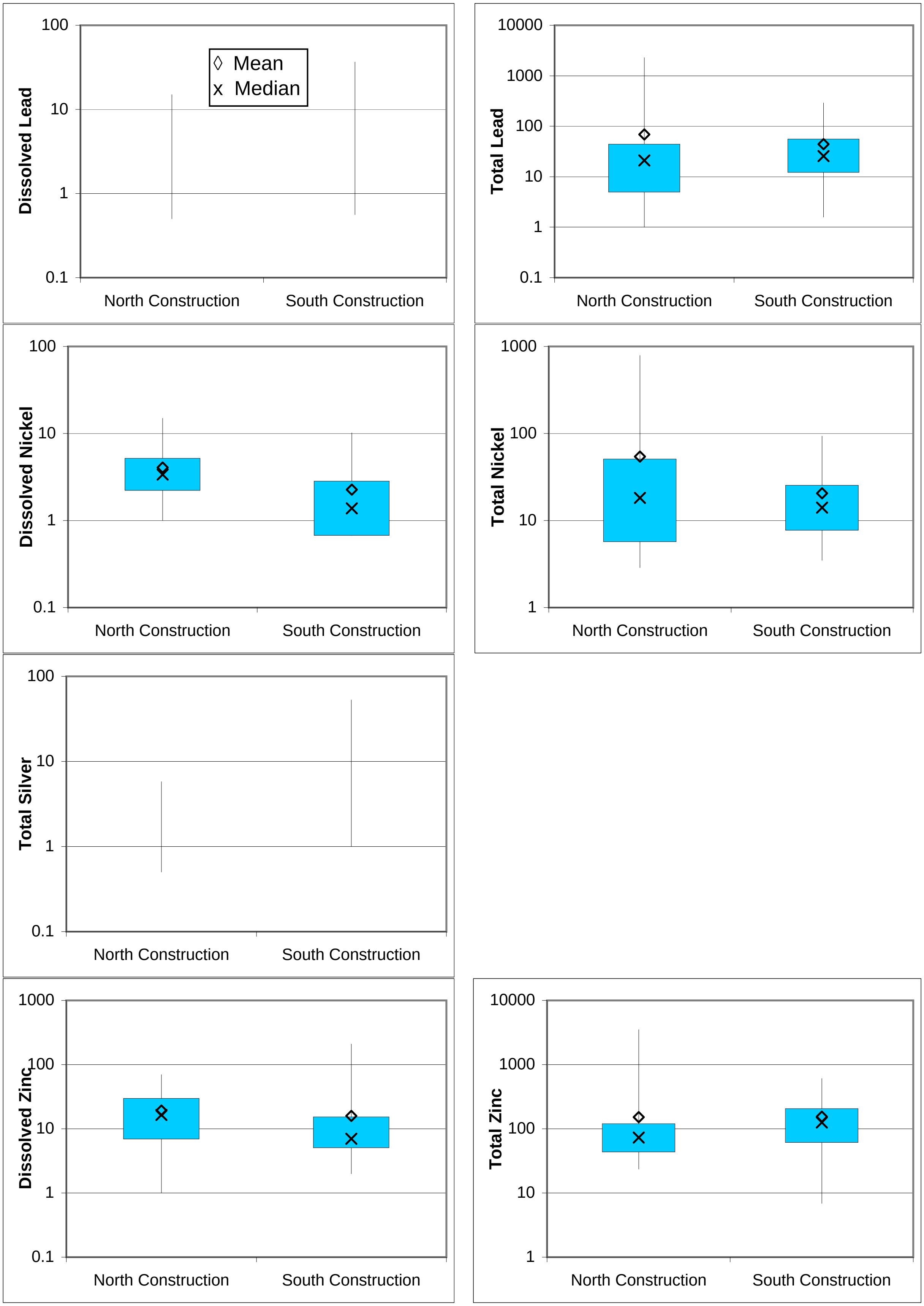


Figure 5-7
North vs South Construction 1998-2002
Metals (ug/L)

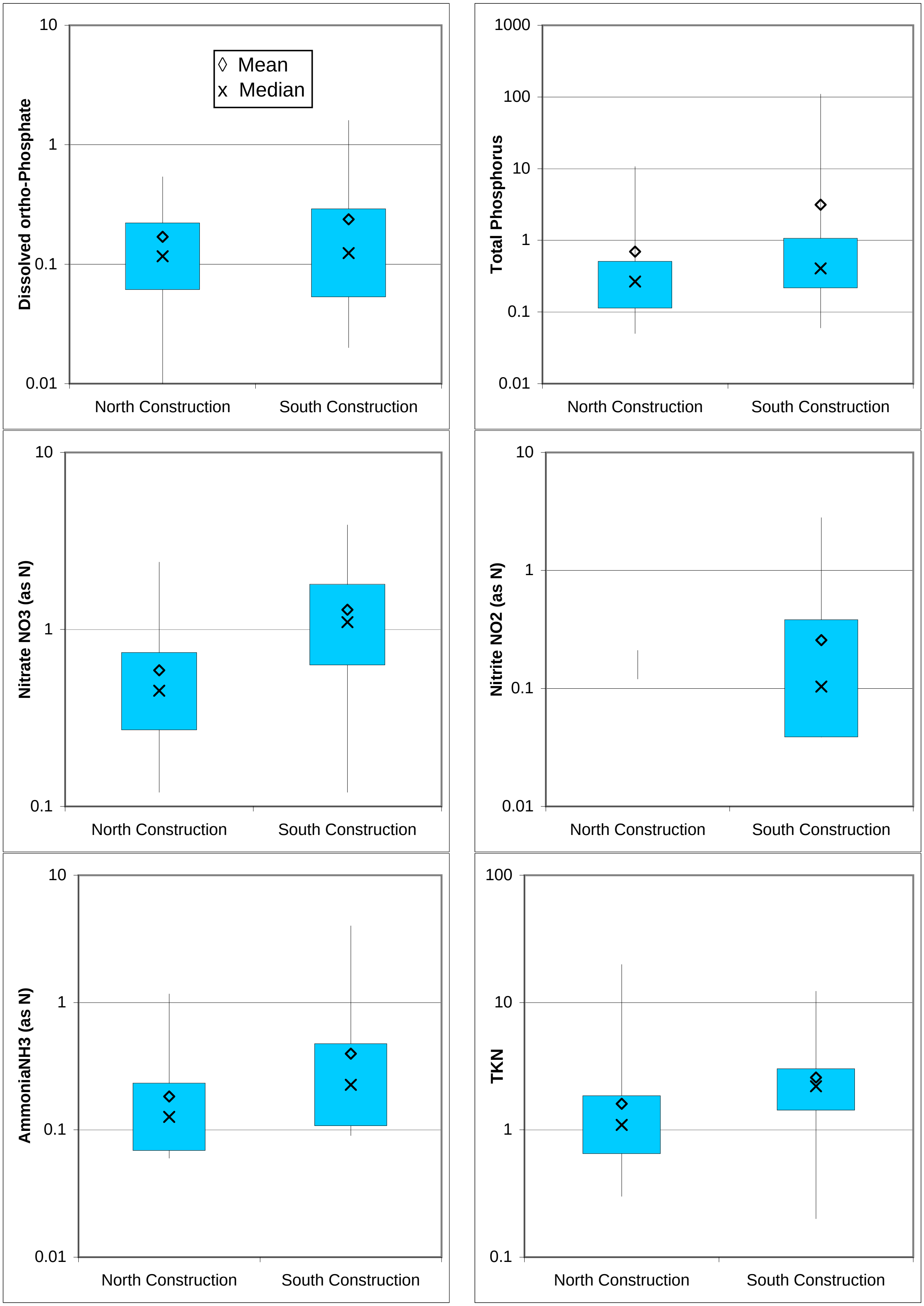
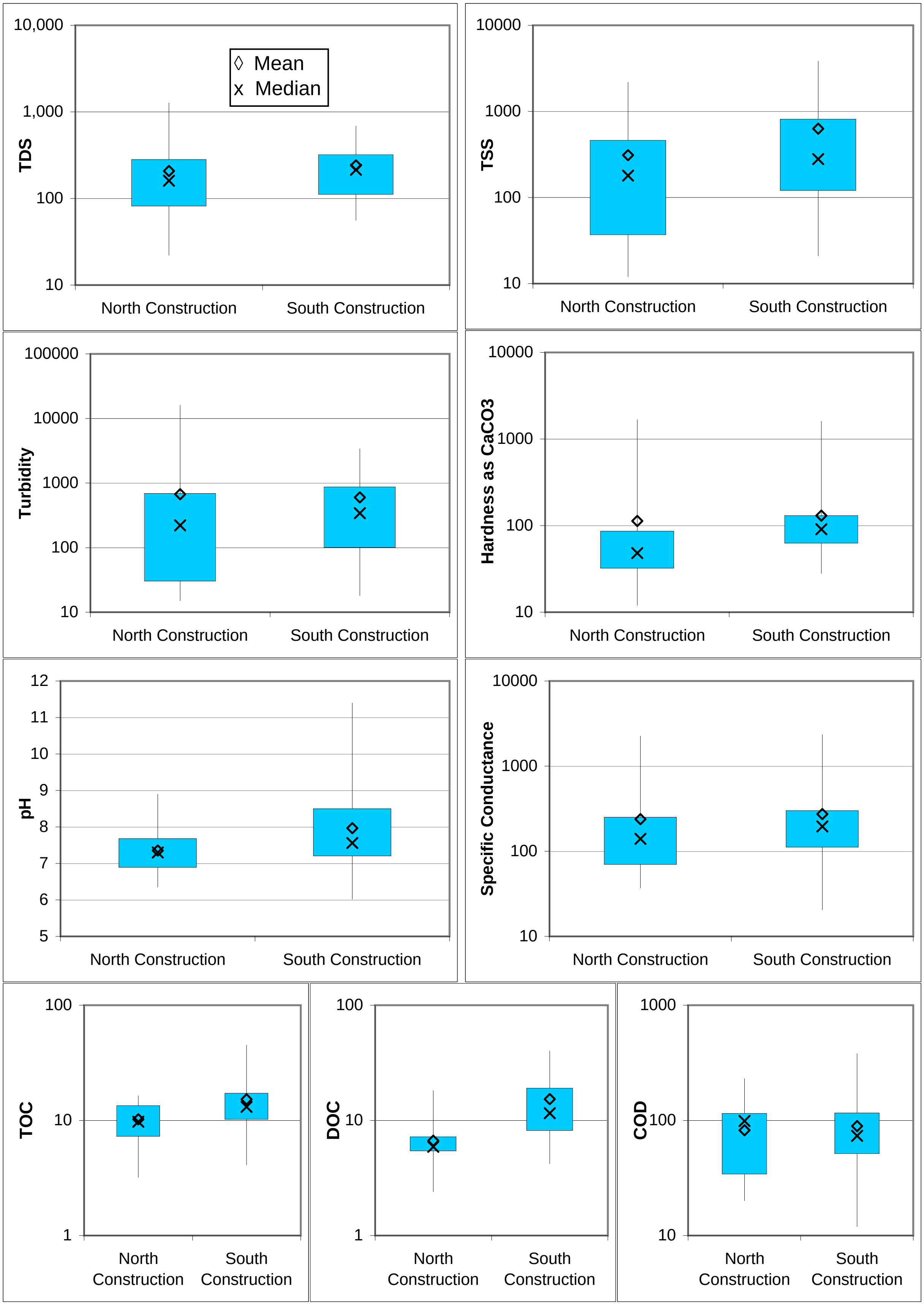
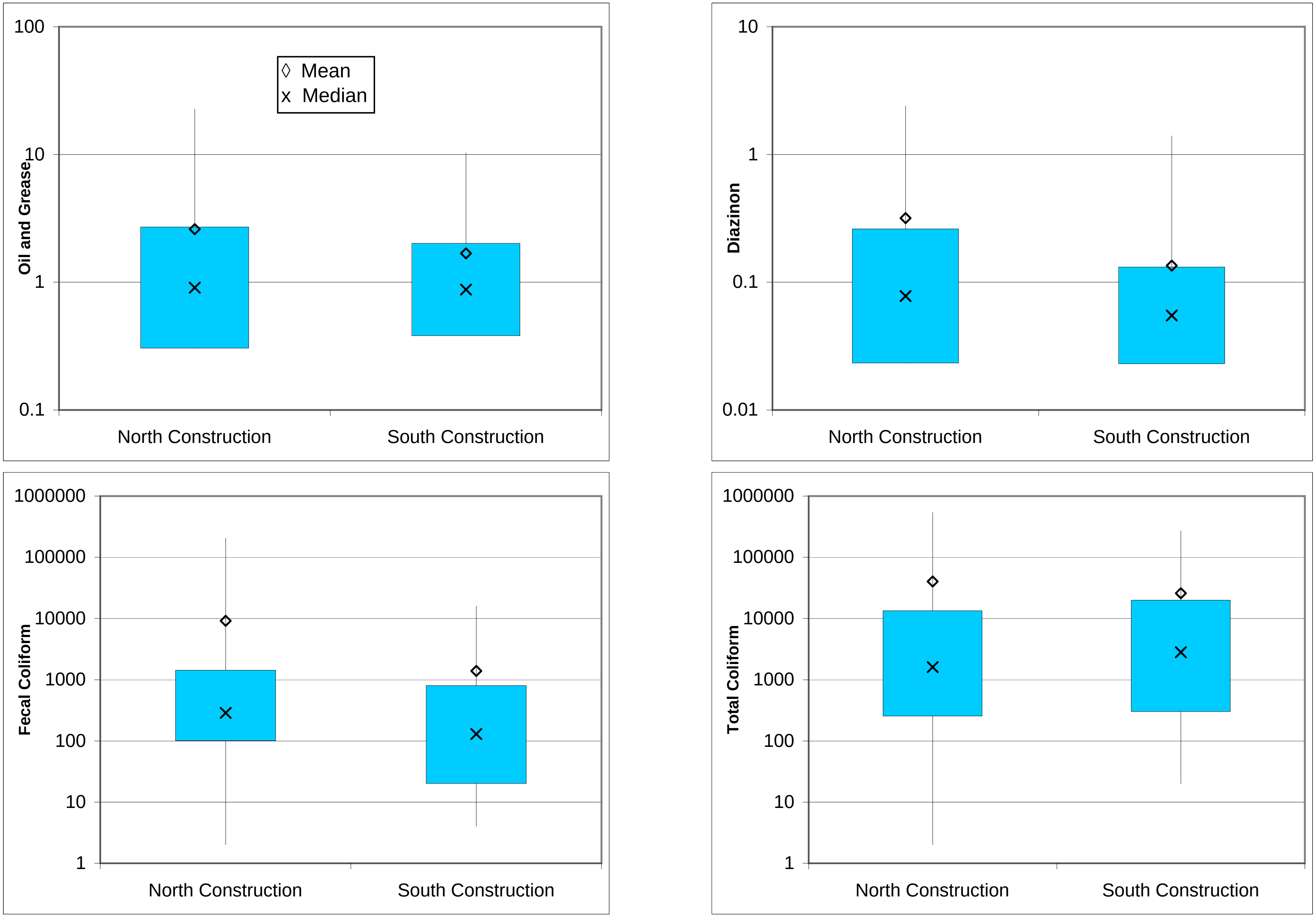


Figure 5-8
North vs South Construction 1998-2002
Nutrients (ug/L)



Turbidity - NTU
pH - pH units
Specific Conductance - umhos/cm

Figure 5-9
North vs South Construction 1998-2002
Conventionals (ug/L)



Oil and Greese - mg/L
Diazinon - ug/L
Coliform - MPN/100ml

Figure 5-10
North vs South Construction 1998-2002
Others (ug/L)

5.1.3 Statistical Comparison of Annual Means

The comparison of the annual means among each of four seasons are shown in Figure 5-11 through 5-15 Statistical significance test results are presented in Table 5-4. Ten constituents show a significant difference between at least two of the means. Contrast (post-hoc) tests were conducted to identify which means are statistically different among the four years for each of the 10 constituents. This information is presented in Table 5-5.

Statistically significant differences exist for Dissolved Ortho-Phosphate, Nitrate, Ammonia, Oil and Grease, Diazinon, Total Coliform, Dissolved Zinc, TDS, TSS, pH, and Specific Conductance. Many constituents with significant differences occur with nutrients and conventionals. With the exception of Dissolved Zinc, no significant differences occur among metals over the 4-year study.

Table 5-4
Statistical Comparison Test on Yearly Mean Concentrations

Constituent	p-value	Significant Difference	Constituent	p-value	Significant Difference
Dissolved Arsenic	0.217	No	Dissolved Lead	0.232	No
Total Arsenic	0.543	No	Total Lead	0.601	No
Dissolved Cadmium	N/A	N/A	Dissolved Nickel	0.357	No
Total Cadmium	0.194	No	Total Nickel	0.276	No
Dissolved Chromium	0.433	No	Dissolved Silver	N/A	N/A
Total Chromium	0.266	No	Total Silver	0.212	No
Dissolved Copper	0.302	No	Dissolved Zinc	0.038	Yes
Total Copper	0.766	No	Total Zinc	0.568	No
Dissolved ortho-Phosphate	0.000	Yes	TDS	0.000	Yes
Total Phosphorus	0.178	No	TSS	0.002	Yes
Nitrate NO3 (as N)	0.090	Yes	Turbidity	0.583	No
Nitrite NO2 (as N)	0.203	No	Hardness as CaCO3	0.960	No
AmmoniaNH3 (as N)	0.012	Yes	pH	0.000	Yes
TKN	0.145	No	Specific Conductance	0.020	Yes
			TOC	0.309	No
Oil and Grease	0.000	Yes	COD	0.638	No
Diazinon	0.000	Yes	DOC	0.168	No
Total Coliform	0.028	Yes			
Fecal Coliform	0.474	No			

(N/A) Too many data points below detection limit. Unable to analyze using Caltrans statistical tool.

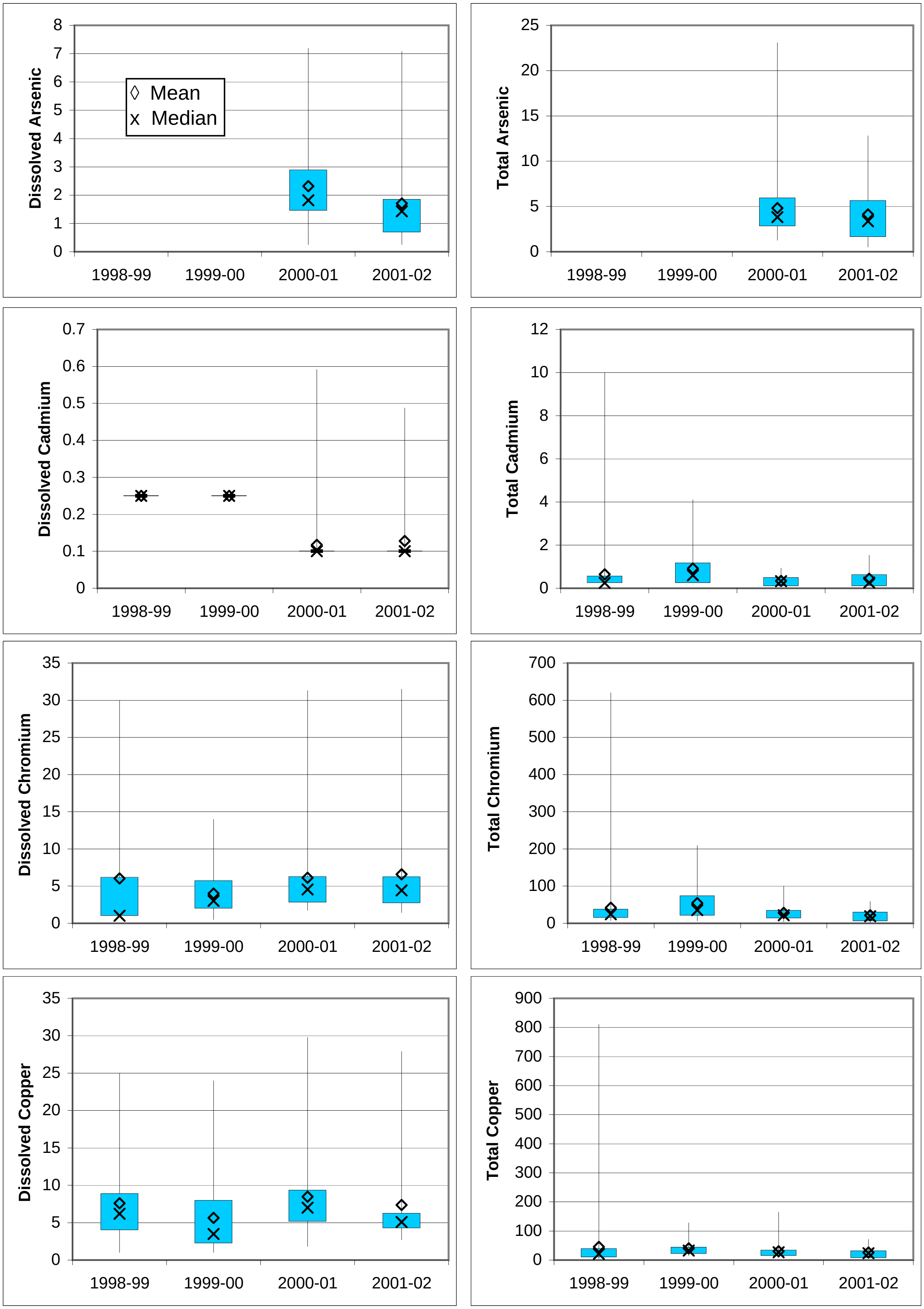


Figure 5-11
Comparison of Annual Means 1998-02
Metals (ug/L)

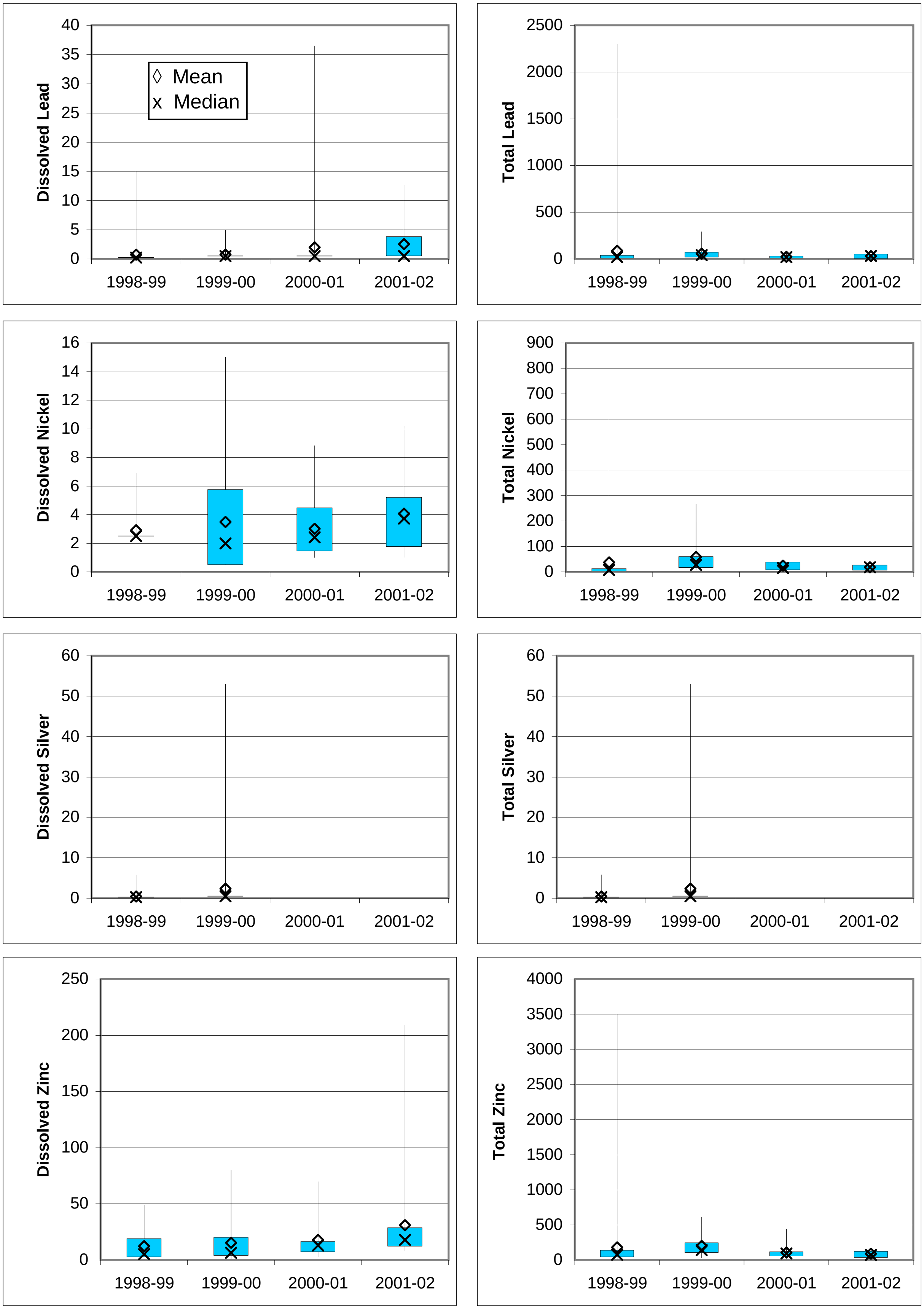


Figure 5-12
Comparison of Annual Means 1998-2002
Metals (ug/L)

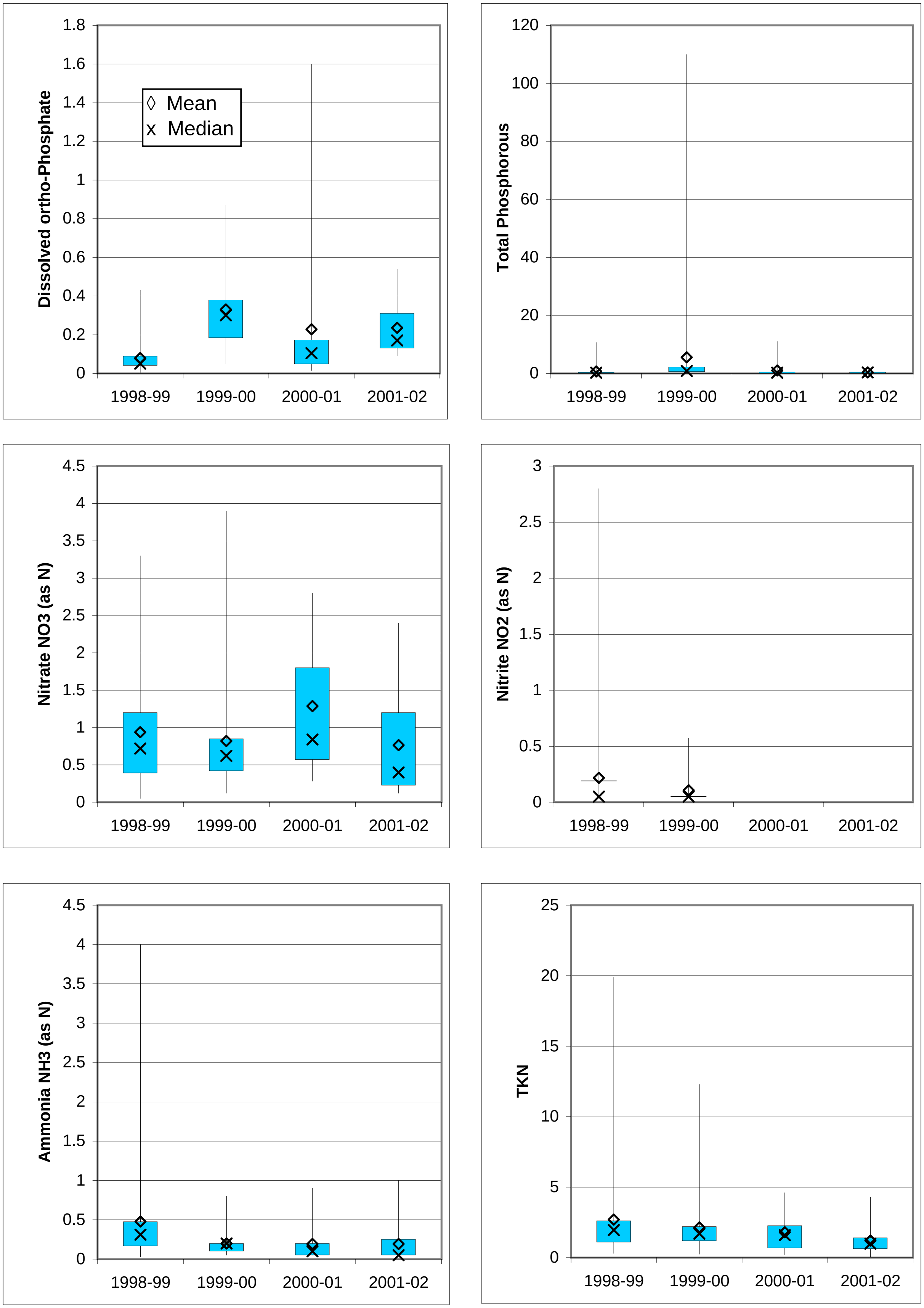
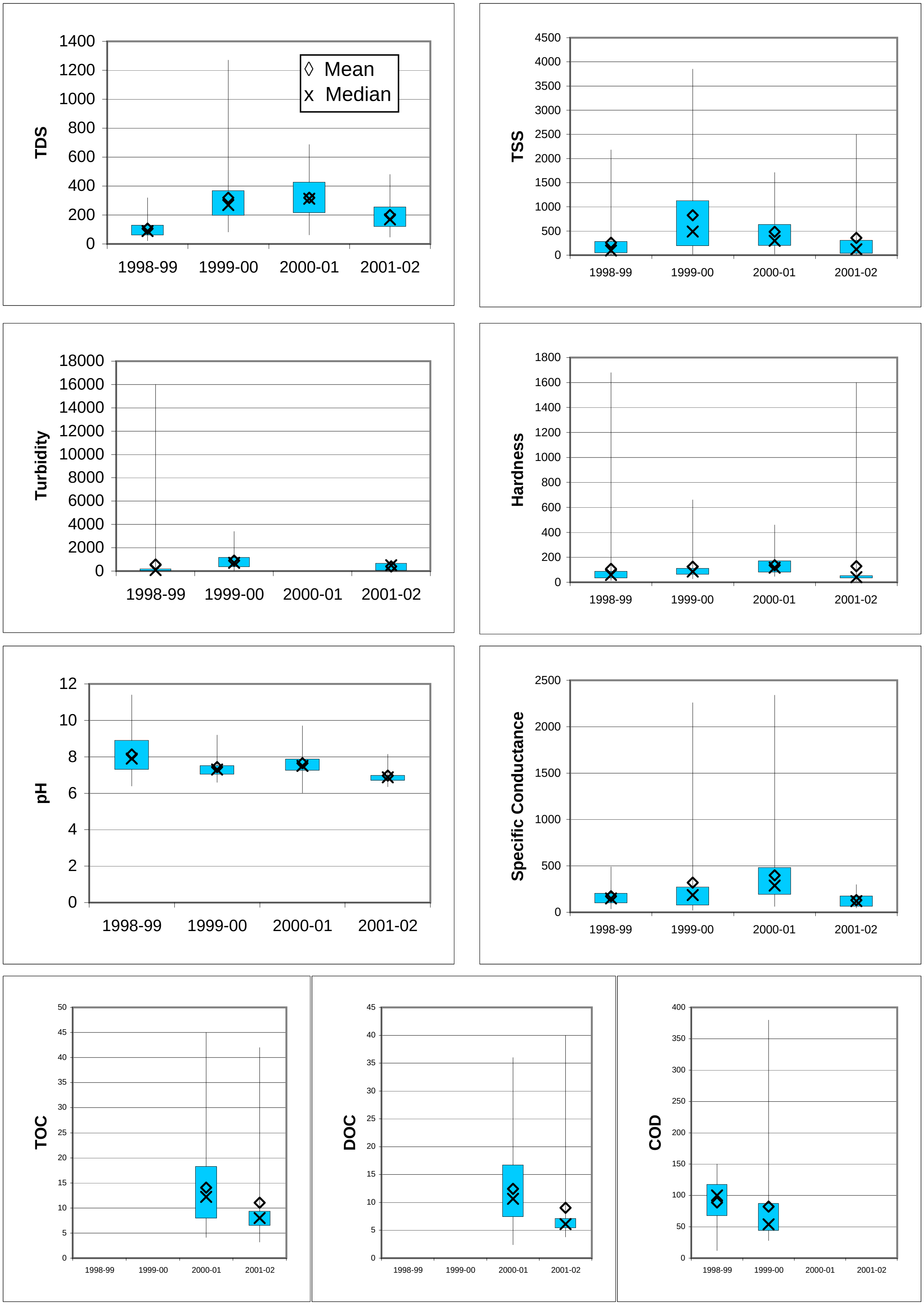
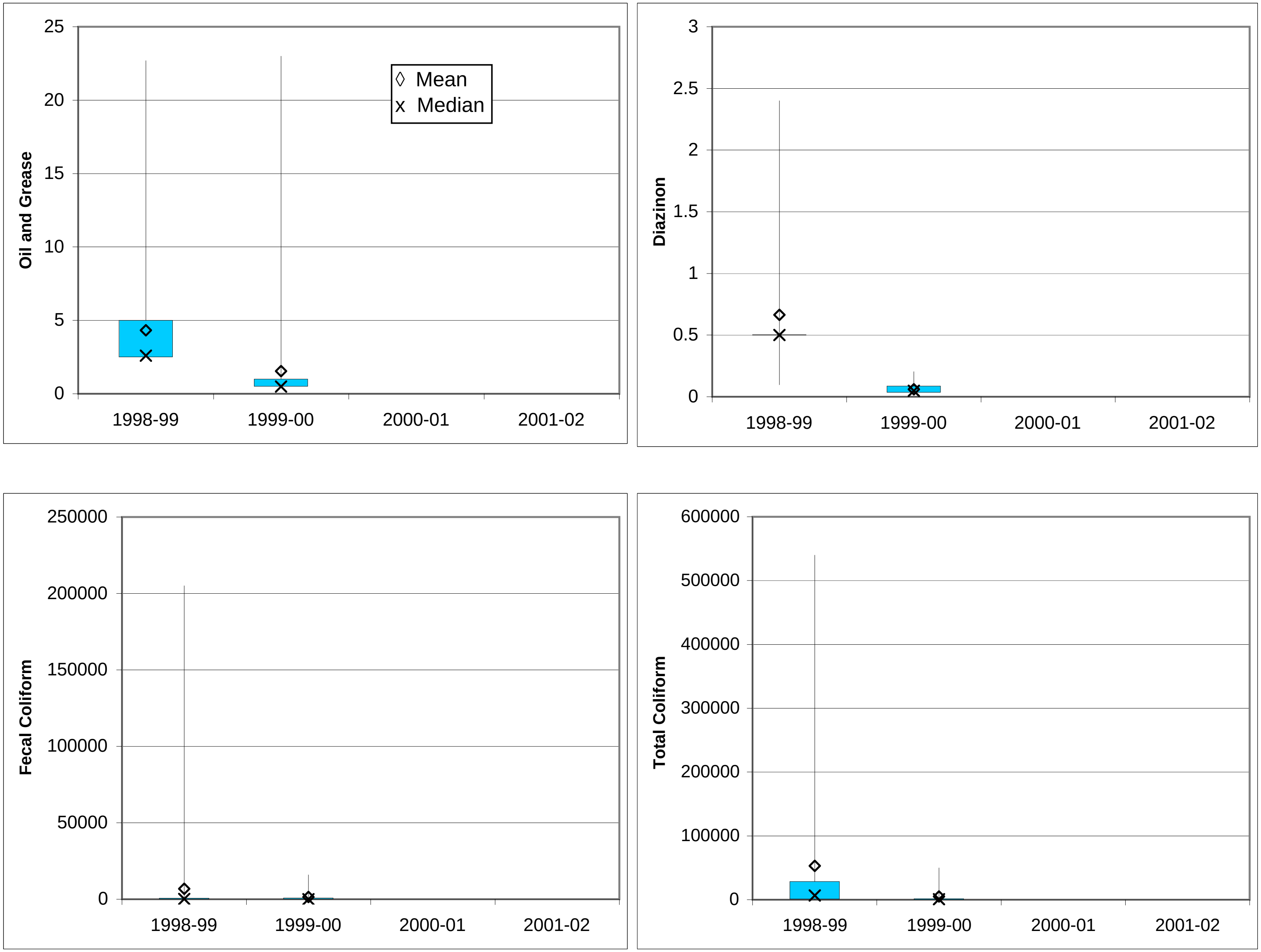


Figure 5-13
Comparison of Annual Means 1998-2002
Nutrients (mg/L)



Turbidity - NTU
pH - pH units
Specific Conductance - umhos/cm

Figure 5-14
Comparison of Annual Means 1998-2002
Conventionals (mg/L)



Oil and Grease - mg/L
Diazinon - ug/L
Coliform - MPN/ 100 mL

Figure 5-15
Comparison of Annual Means 1998-2002
Others

Table 5-5

Annual Mean Values of Constituents Showing a Statistically Significant Difference Over the Four-Year Study

Constituent	1998-1999	1999-2000	2000-2001	2001-2002	Comments
Dissolved ortho-Phosphate	0.08	0.33	0.23	0.24	Low in 1998-1999
Nitrate NO3 (as N)	0.93	0.82	1.29	0.76	High in 2000-2001
Ammonia NH3 (as N)	0.48	0.20	0.19	0.19	Low in 1998-1999
Oil and Grease	4.32	1.54	-	-	1998-1999 differs from 1999-2000
Diazinon	0.66	0.06	-	-	1998-1999 differs from 1999-2000
Total Coliform	52,878.80	5,084.61	-	-	1998-1999 differs from 1999-2000
Dissolved Zinc	12.33	15.30	18.01	30.95	High in 2001-2002
TDS	105.38	319.83	319.5	200.53	Low in 1998-1999
TSS	258.66	827.97	485.39	355.58	High in 1999-2000
pH	8.13	7.44	7.65	6.98	High in 1998-1999, Low in 2001-02
Specific Conductance	174	319	399	131	High in 1999-2000 and 2000-2001

5.2 Construction Site Data vs. Highway Data

The construction site storm water data was compiled and compared to (1) Caltrans highway data and (2) data from other highway and freeway agencies. Box plots were produced for the comparison with Caltrans highway data. The statistical significance test was conducted to determine significant difference in data. Individual data points for other agencies' highway and freeway were not available for comparison to construction site storm water data. However, bar charts showing comparison of mean values were produced. These are discussed in Section 5.2.2.

5.2.1 Comparison to Caltrans Highway Data

The Caltrans Highway data has been compiled from Caltrans highway storm water monitoring projects over the past four years. Constituents are compared that are common to both construction site and highway storm water monitoring during the same four-year period. Box plots for the comparison are shown in Figures 5-16 through 5-20. The statistical significance test results are presented in Table 5-6.

In the metals comparison, concentrations for Total Cadmium, Dissolved Copper, Dissolved Lead, Total and Dissolved Zinc are significantly higher for highway runoff, while Dissolved Arsenic, Dissolved Chromium, Total Chromium, and Total Nickel were higher for construction sites. In the comparison of conventional constituents, Dissolved Ortho-Phosphate and Total Phosphorus were higher at construction sites, while Ammonia was higher at highway sites. In the comparison of conventional constituents, TSS and Hardness are significantly higher for construction site runoff than highway runoff, while COD is higher for highway runoff. Oil and grease is higher for highway runoff.

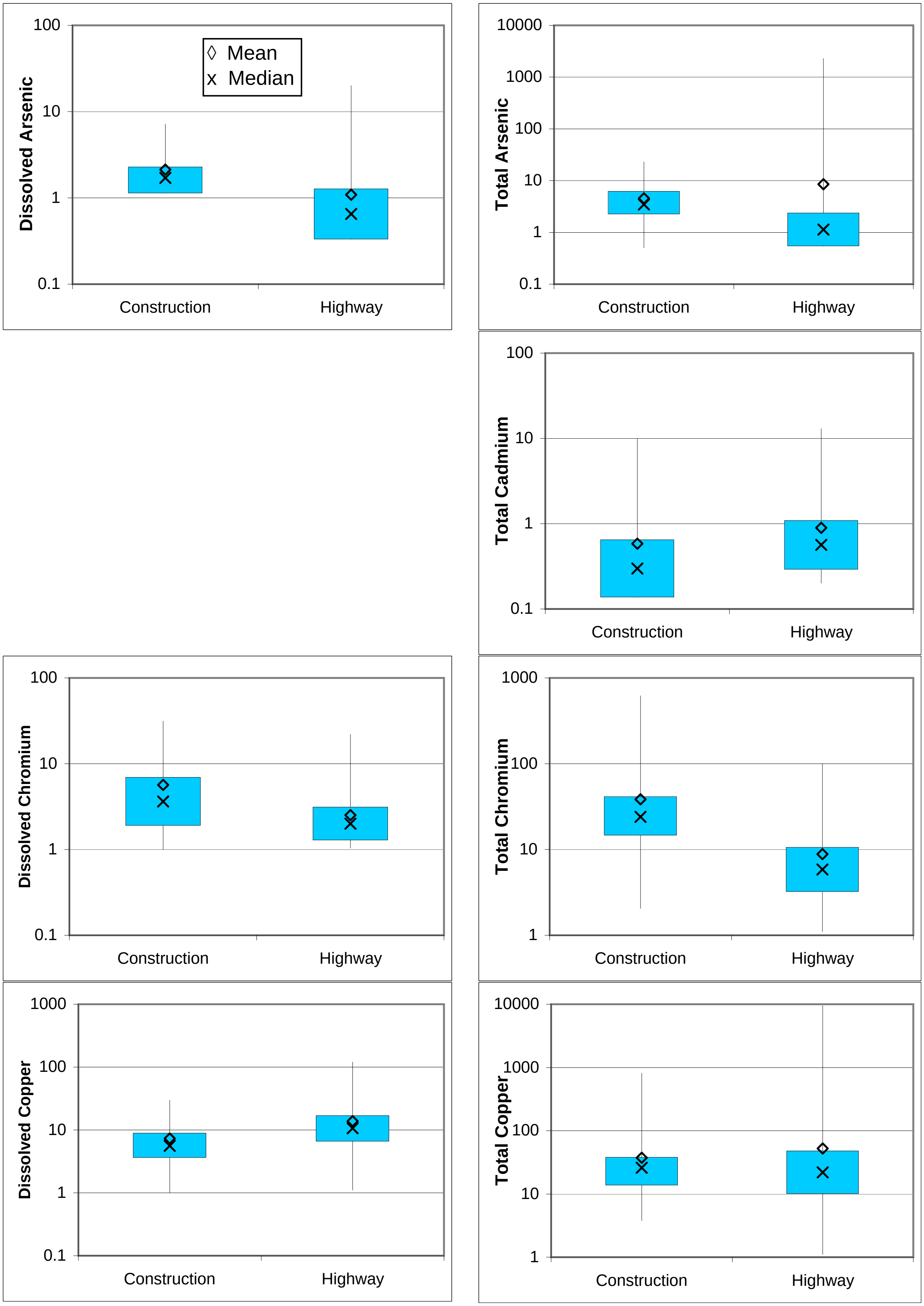


Figure 5-16
Construction vs Highway Runoff
Metals (ug/L)

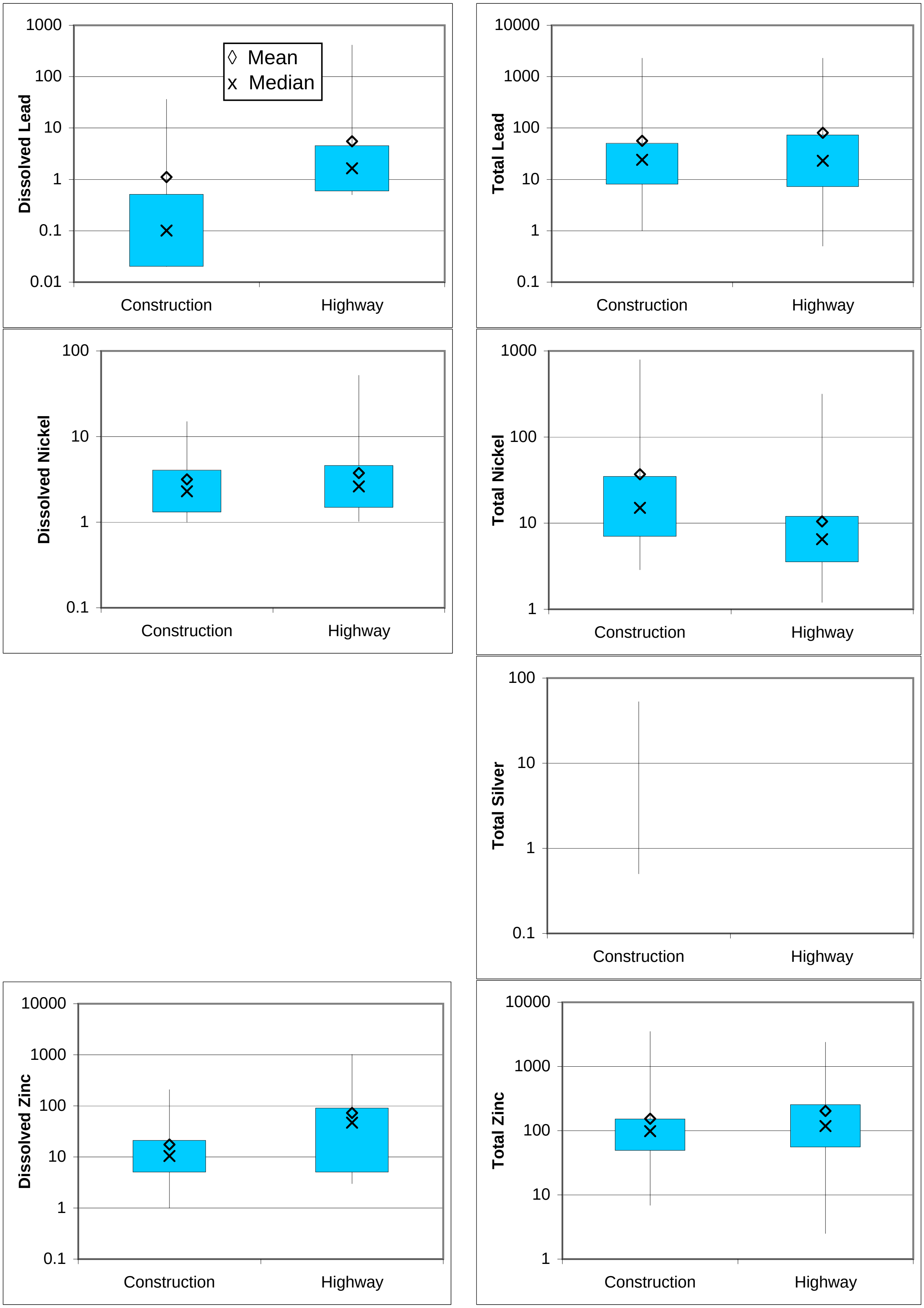


Figure 5-17
Construction vs Highway Runoff
Metals (ug/L)

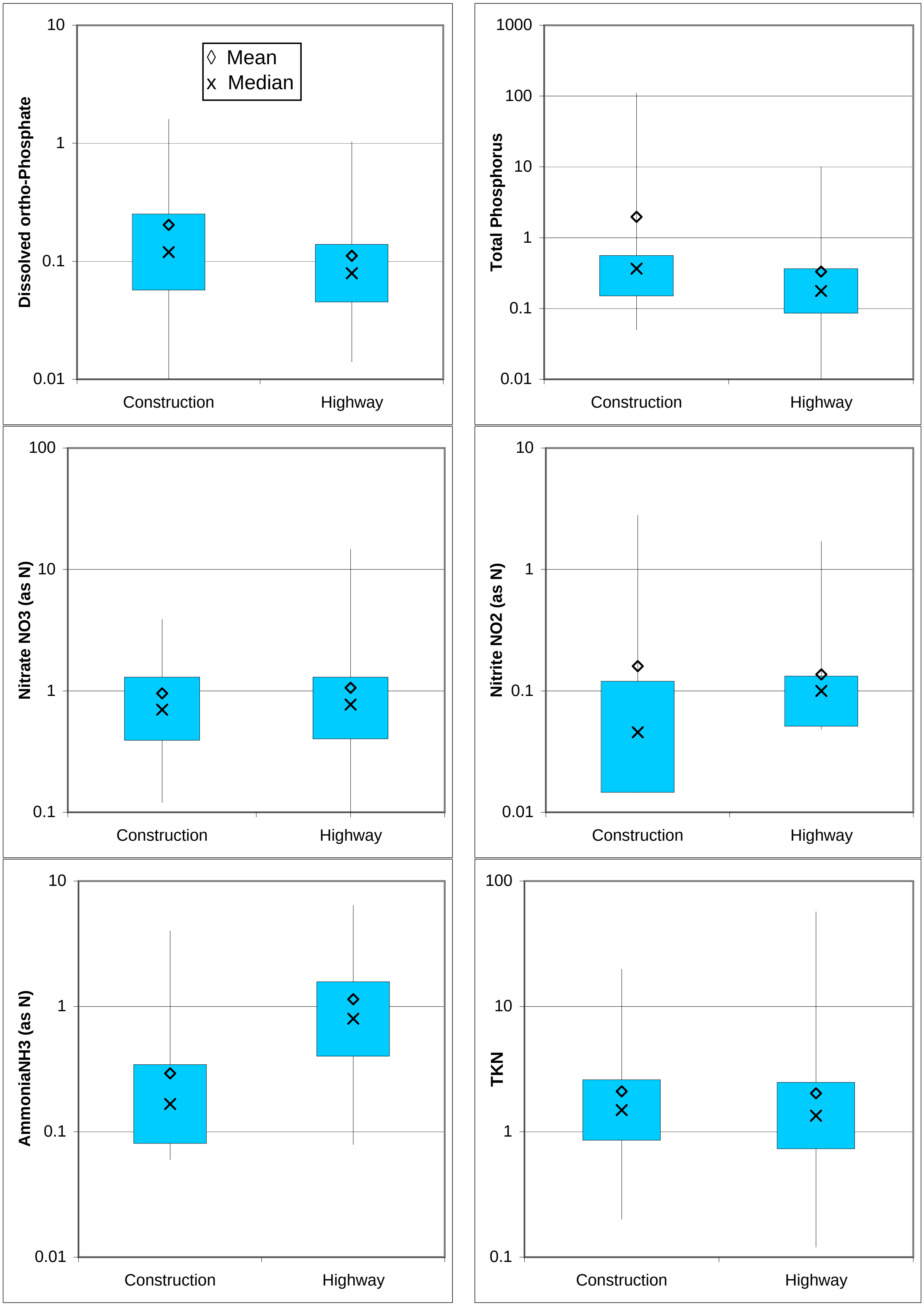
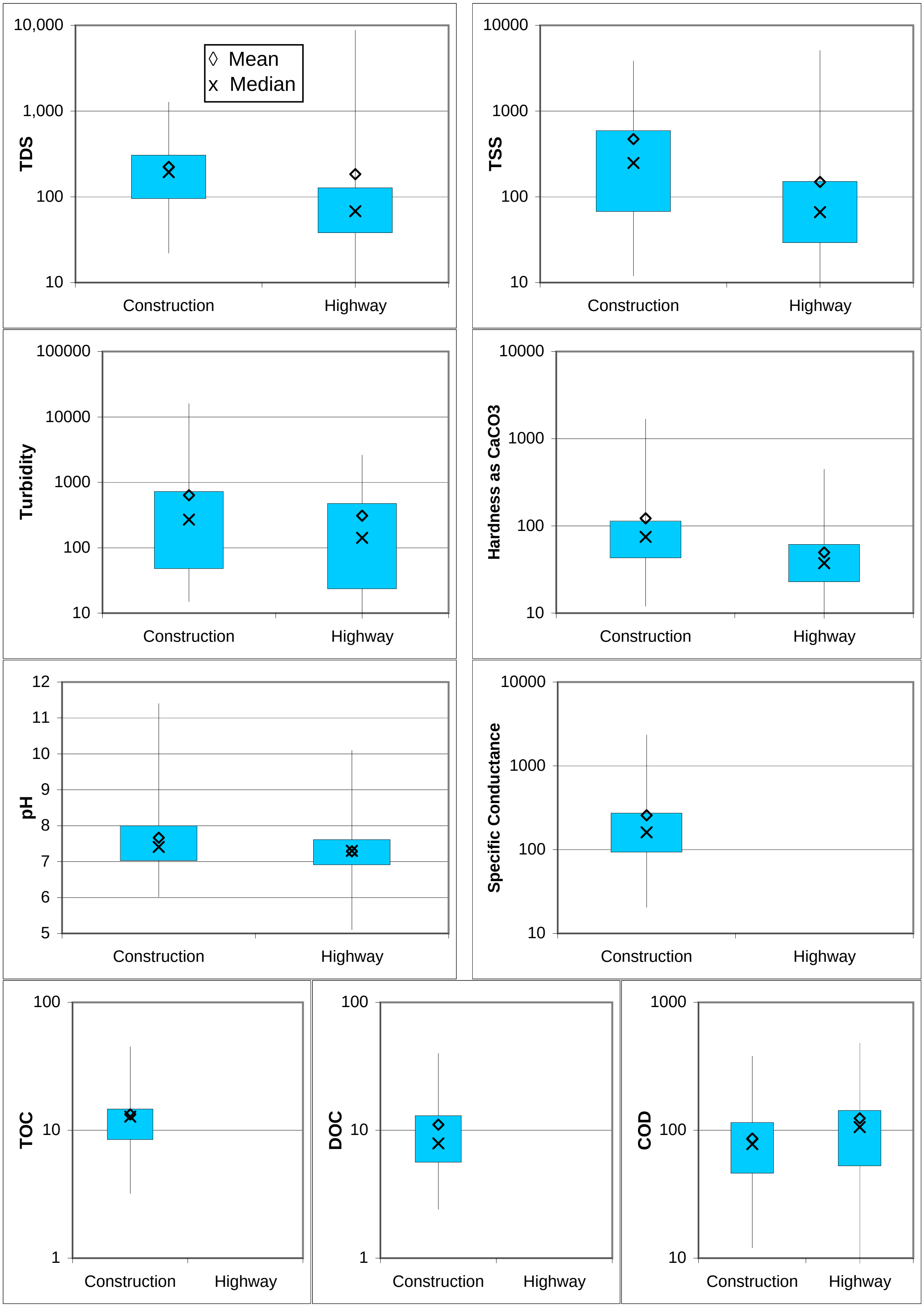
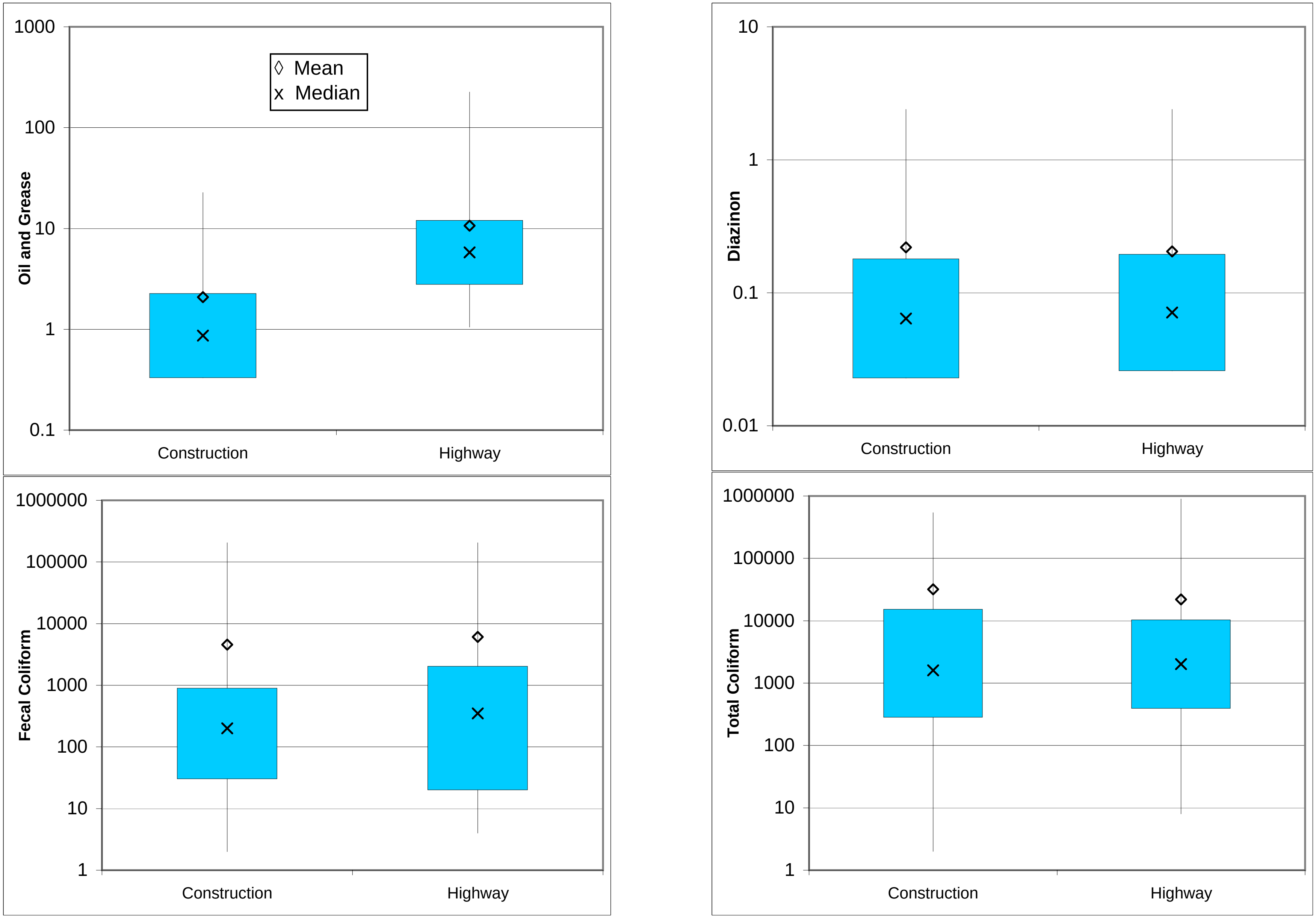


Figure 5-18
Construction vs Highway Runoff
Nutrients (mg/L)



Turbidity - NTU
pH - pH units
Specific Conductance - umhos/cm

Figure 5-19
Construction vs Highway Runoff
Conventionals (mg/L)



Oil and Grease - mg/L
Diazinon - ug/L
Coliform - MPN/ 100mL

Figure 5-20
Construction vs Highway Runoff
Others

Table 5-6

Statistical Comparison Test on Construction vs. Caltrans Highway Runoff

Constituent	p-value	Significant Difference	Constituent	p-value	Significant Difference
Dissolved Arsenic	0.0001	Yes	Dissolved Lead	0.0218	Yes
Total Arsenic	0.8812	No	Total Lead	0.2188	No
Dissolved Cadmium		N/A	Dissolved Nickel	0.1414	No
Total Cadmium	0.0044	Yes	Total Nickel	0.0000	Yes
Dissolved Chromium	0.0000	Yes	Dissolved Silver		N/A
Total Chromium	0.0000	Yes	Total Silver		N/A
Dissolved Copper	0.0000	Yes	Dissolved Zinc	0.0000	Yes
Total Copper	0.7397	No	Total Zinc	0.0656	Yes
Dissolved ortho-Phosphate	0.0000	Yes	TDS	0.5408	No
Total Phosphorus	0.0007	Yes	TSS	0.0000	Yes
Nitrate NO3 (as N)	0.3525	No	Turbidity	0.3271	No
Nitrite NO2 (as N)	0.6451	No	Hardness as CaCO3	0.0000	Yes
AmmoniaNH3 (as N)	0.0000	Yes	pH	0.0000	Yes
TKN	0.7781	No	Specific Conductance		N/A
			TOC		N/A
Oil and Grease	0.0000	Yes	COD	0.0078	Yes
Diazinon	0.8309	No	DOC		N/A
Total Coliform	0.2849	No			
Fecal Coliform	0.6311	No			

5.2.2 Comparison to Other Highway and Freeway Data

Table 5-7 presents a comparison between the summary of the data collected during the 1998-02 monitoring seasons from the construction sites and the summary of 1995 data from the Texas Department of Transportation (TDT) and the 1990 data from the Federal Highways Administration (FHWA). Also for comparison purpose are the mean values of Caltrans Highway data discussed in the previous section. The data is compared by individual parameters in Figures 5-21 through 5-23. No data was available for comparison in TDT and FHWA for dissolved metals. The following is a summary of the comparisons.

- Mean concentrations of metals are lower for construction site runoff than FHWA runoff. This is also true for Caltrans highway runoff with the exception of Nickel and Chromium. Mean concentrations of metals for construction site runoff are not lower than TDT runoff.

- Mean concentrations of Nitrate and TKN (nutrients) are higher from construction site runoff than TDT and FHWA runoff. Mean concentrations of nutrients for construction site runoff are higher than Caltrans highway runoff with the exception of Nitrate and Ammonia.

- With the exception of COD, mean concentrations of conventional pollutants are higher for construction site runoff than Caltrans highway, TDT, and FHWA runoff.

Table 5-7

Summary of Water Quality Data for Caltrans Construction Site Runoff and Texas DOT/ FHWA

Constituent	Caltrans Construction	Caltrans Highway 1998-02	Texas DOT 1995	FHWA 1990
Total Metals (ug/L)				
Arsenic Total	4.54	8.55		
Cadmium Total	0.58	0.90		20
Chromium Total	38.60	8.83		
Copper Total	37.20	52.36	11	54
Lead Total	56.41	80.90	11	400
Nickel Total	37.03	10.49	25	
Silver Total				
Zinc Total	153.73	203.51		399
Nutrients (mg/L)				
Phosphorus Dissolved	0.20	0.11	0.1	0.4
Phosphorus Total	1.96	0.33	0.2	
Nitrate (as N)	0.95	1.06	0.7	0.8
Nitrite (as N)	0.16	0.14		
Ammonia	0.29	1.14		
TKN	2.11	2.03	1.2	1.8
Conventional Pollutants (mg/L)				
Hardness	121.69	49.62		
Suspended Solids	472.81	148.93	90	142
Dissolved Solids	225.02	184.14	158	
Turbidity (NTU)	636.4	310.07		
COD	86.06	123.75	59	114

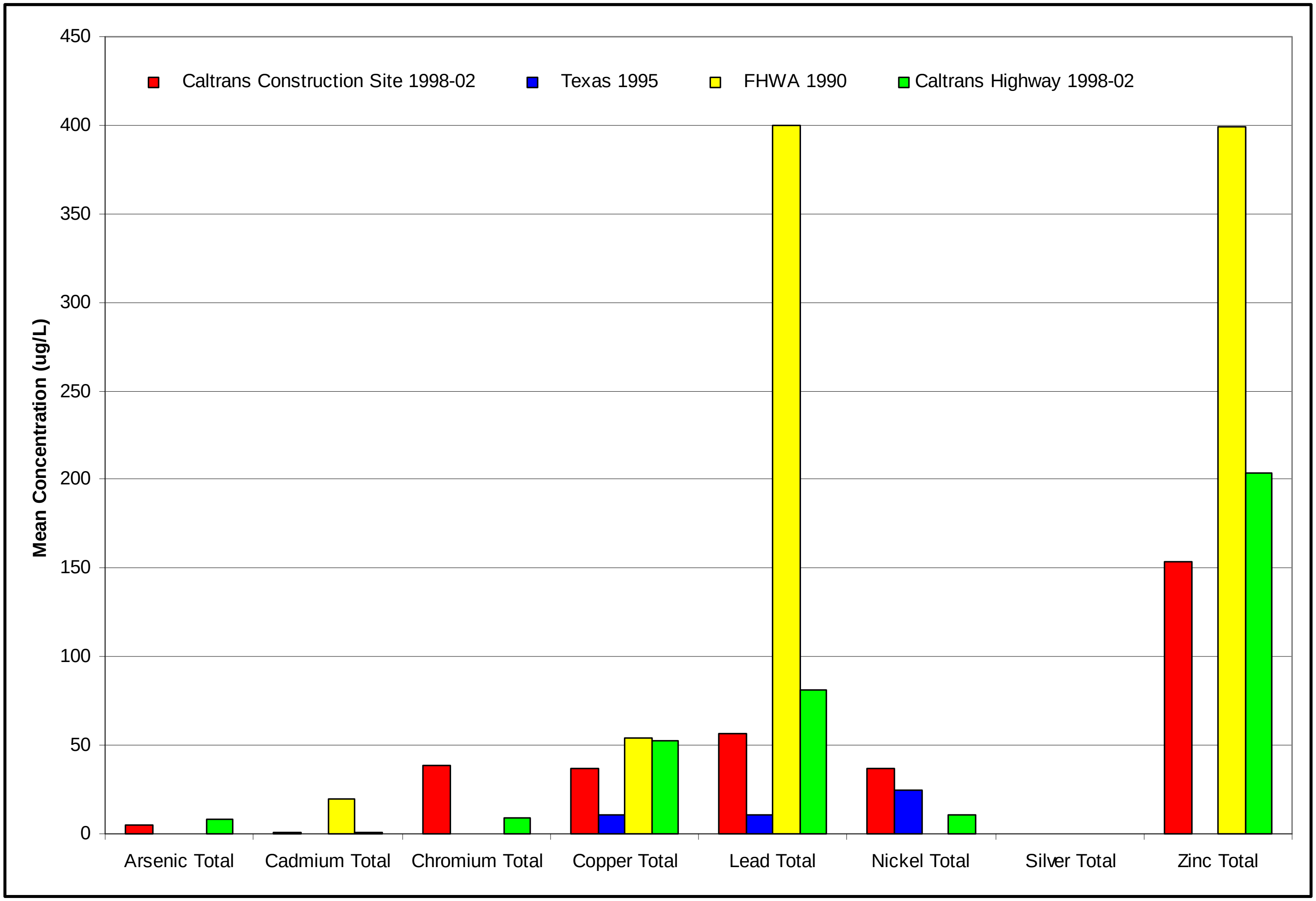


Figure 5-21
Comparison of Total Metals Mean Concentration Between
Construction Site Storm Water 1998-2002 Monitoring Seasons and Highway Data

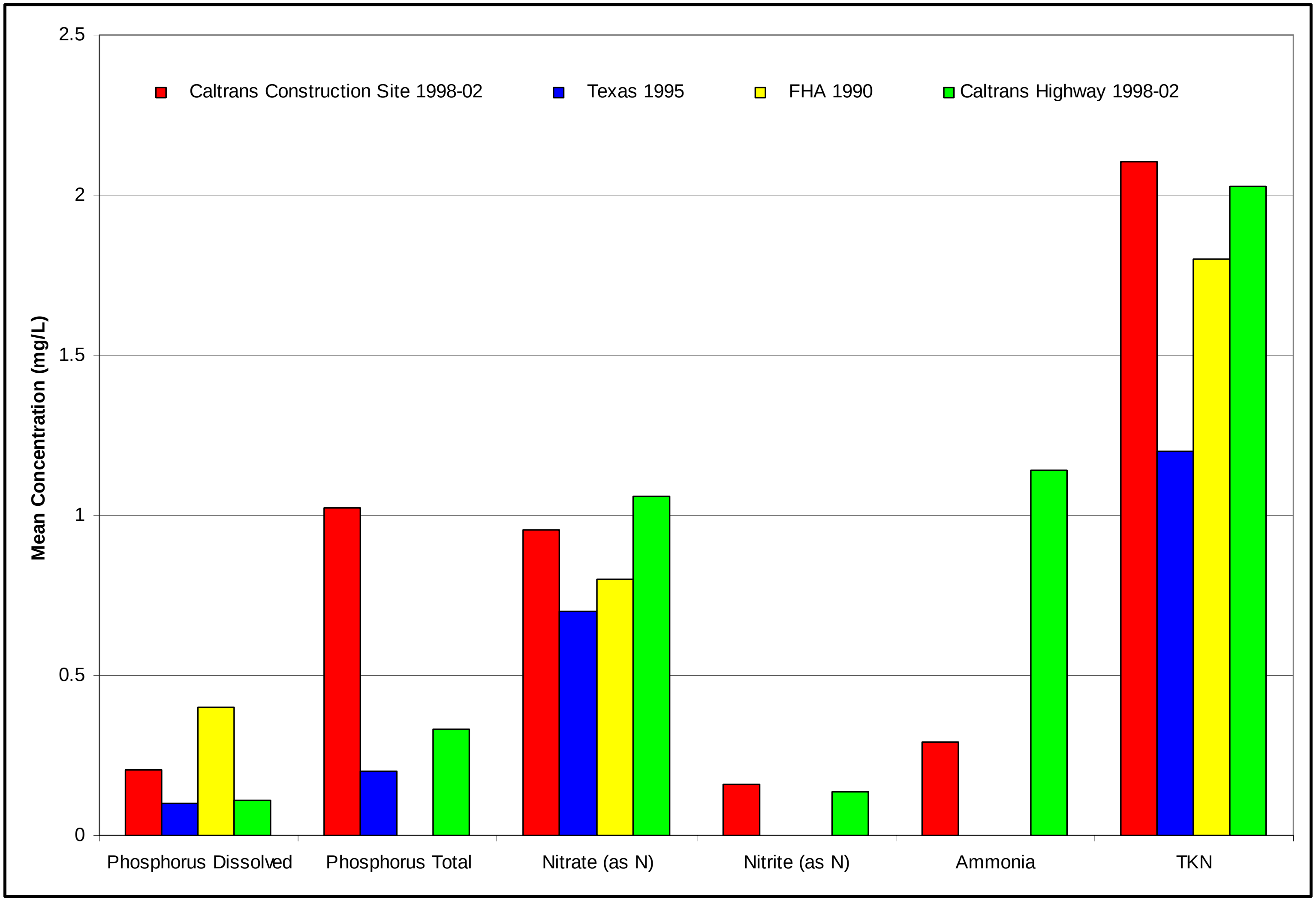


Figure 5-22
Comparison of Nutrients Mean Concentration Between
Construction Site Storm Water 1998-2002 Monitoring Seasons and Highway Data

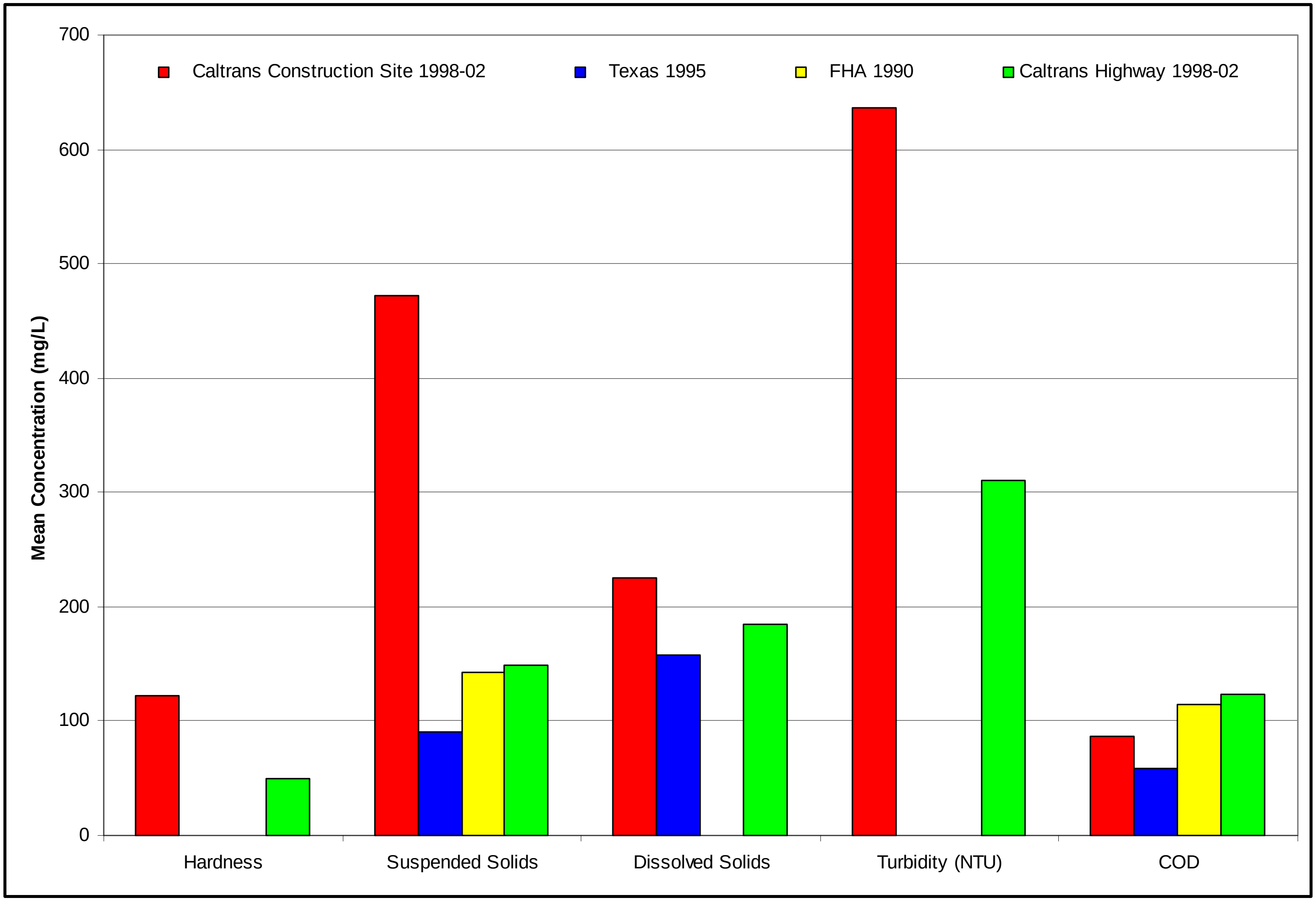


Figure 5-23
Comparison of Conventional Pollutants Mean Concentration Between
Construction Site Storm Water 1998-2002 Monitoring Seasons and Highway Data

5.3 Correlation Between TSS and Chemical Constituents

For the combined data from the four monitoring years, correlations were developed for TSS against particulate concentrations of Arsenic, Cadmium, Chromium, Copper, Lead, Nickel, and Zinc. This was done to determine if a relationship exists between suspended matter or sediment and the construction monitoring list of constituents. Particulate metals concentrations were obtained by subtracting the dissolved value from the total. This relationship is of interest since much of the focus of construction site BMP practices is on erosion control and sediment removal from runoff. A good correlation suggests that effective sediment control may help secure a reduction in other pollutants.

Figures 5-24 through 5-30 depict the correlation between TSS and individual particulate metals. In each of the figures, there is an outlier. Trendlines were obtained with and without the outlier. In four of the six figures, the R^2 increased when the outlier was removed.

High correlation is suggested when R^2 values are greater than 0.5. In the figures, the highest correlations are for TSS vs Particulate Copper (R^2 = 0.59), for TSS vs Particulate Zinc (R^2 = 0.49), and TSS vs Particulate Chromium (R^2 = 0.39). In all cases, the high correlation occurs only when the outlier is removed. Before removal of the outliers, the two constituents having the highest correlation with TSS are Particulate Chromium (R^2 =0.2773) and Particulate Copper (R^2 = 0.2279).

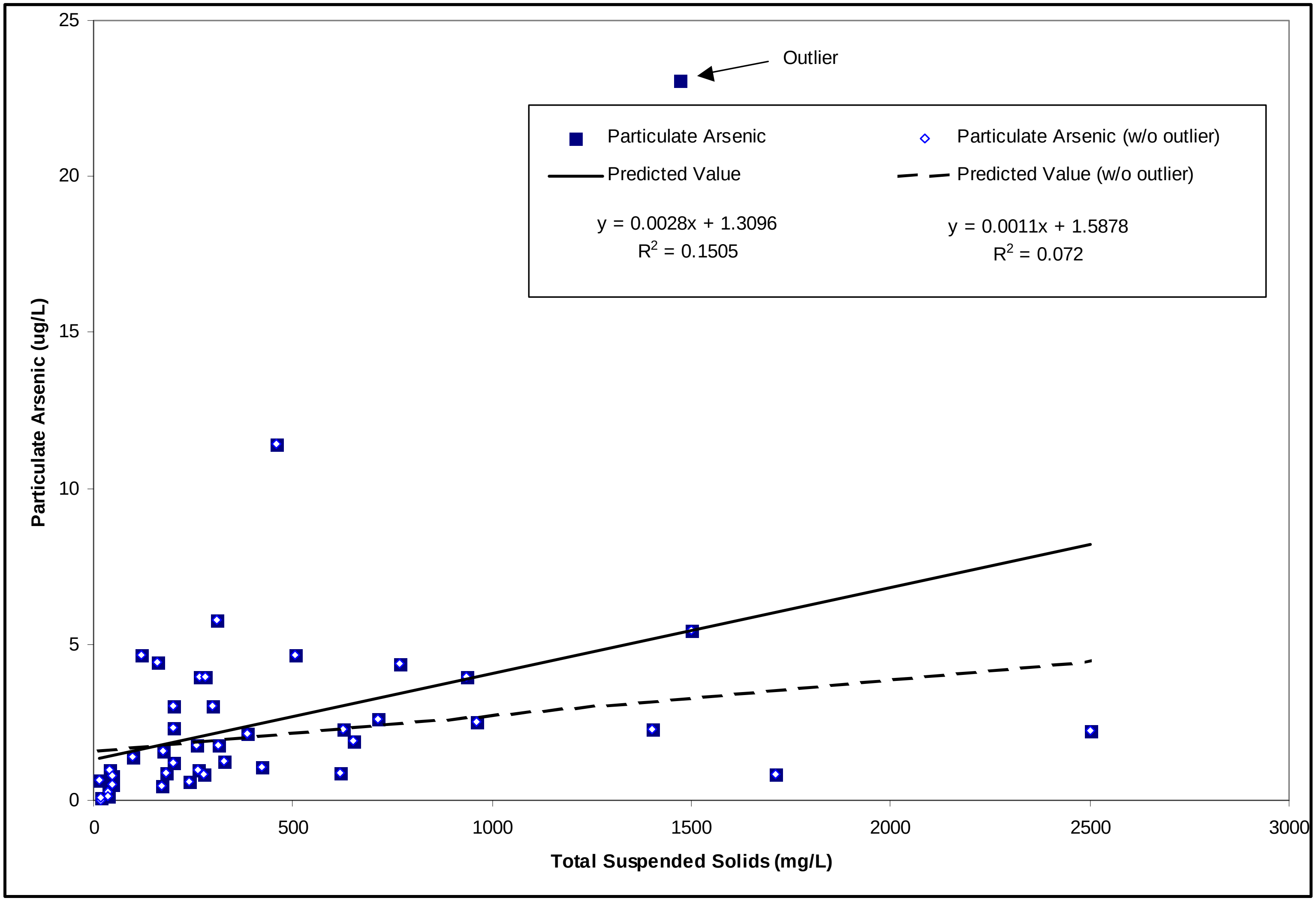


Figure 5-24
Correlation Between TSS and Particulate Arsenic for
Construction Site Runoff Characterization Study During the Past Four Years

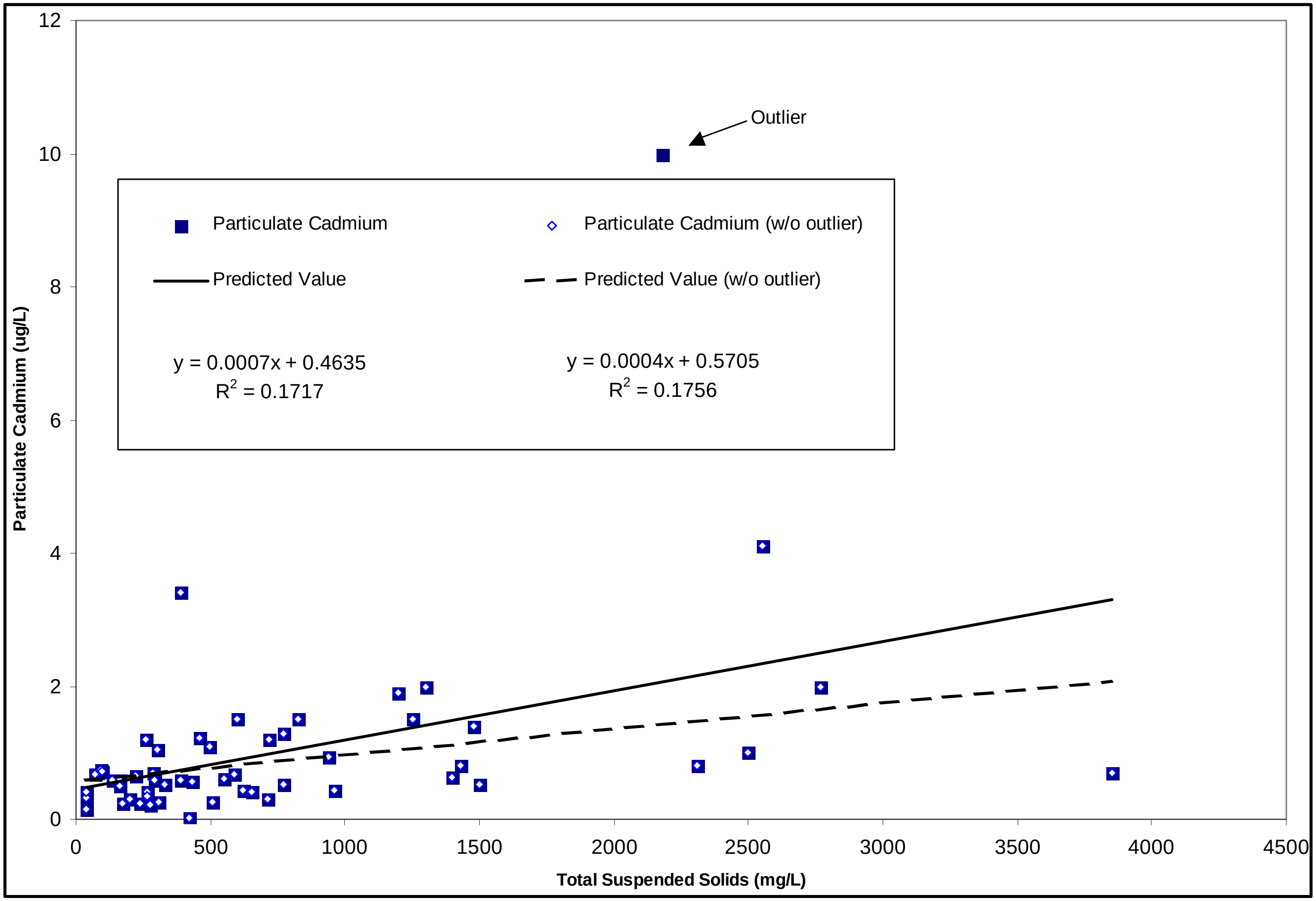


Figure 5-25
Correlation Between TSS and Particulate Cadmium for
Construction Site Runoff Characterization Study During the Past Four Years

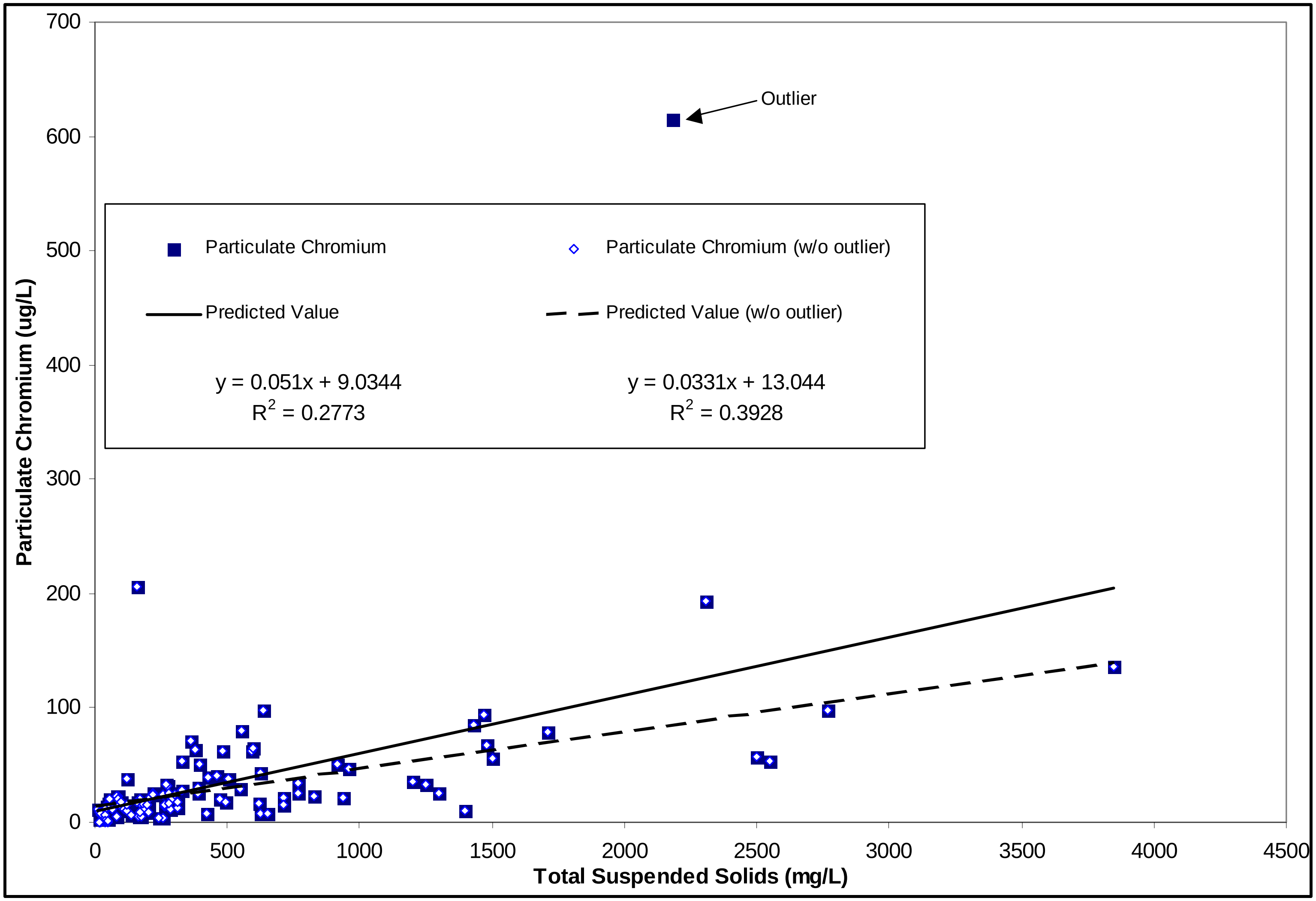


Figure 5-26
Correlation Between TSS and Particulate Chromium for
Construction Site Runoff Characterization Study During the Past Four Years

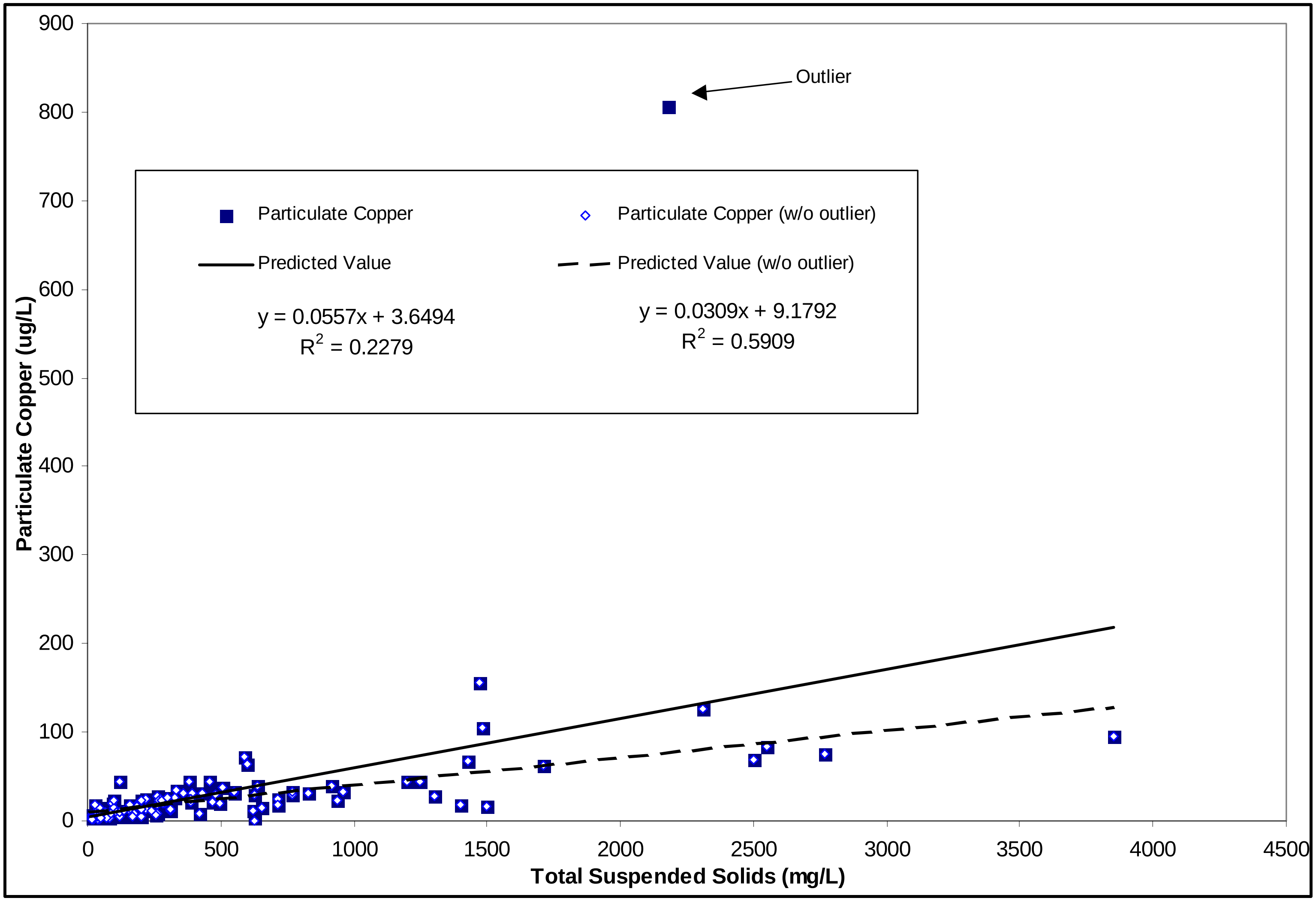


Figure 5-27
Correlation Between TSS and Particulate Copper for
Construction Site Runoff Characterization Study During the Past Four Years

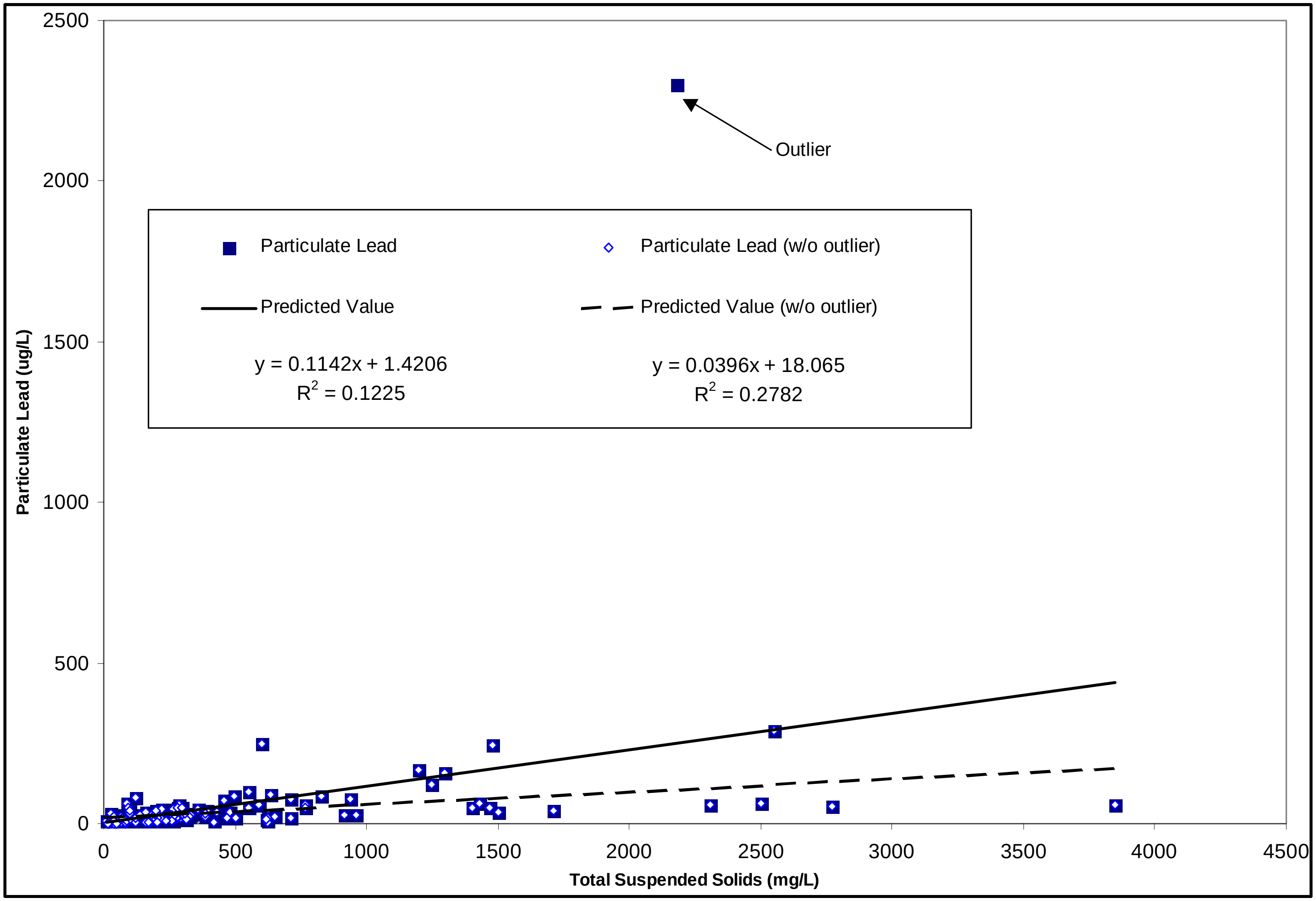


Figure 5-28
Correlation Between TSS and Particulate Lead for
Construction Site Runoff Characterization Study During the Past Four Years

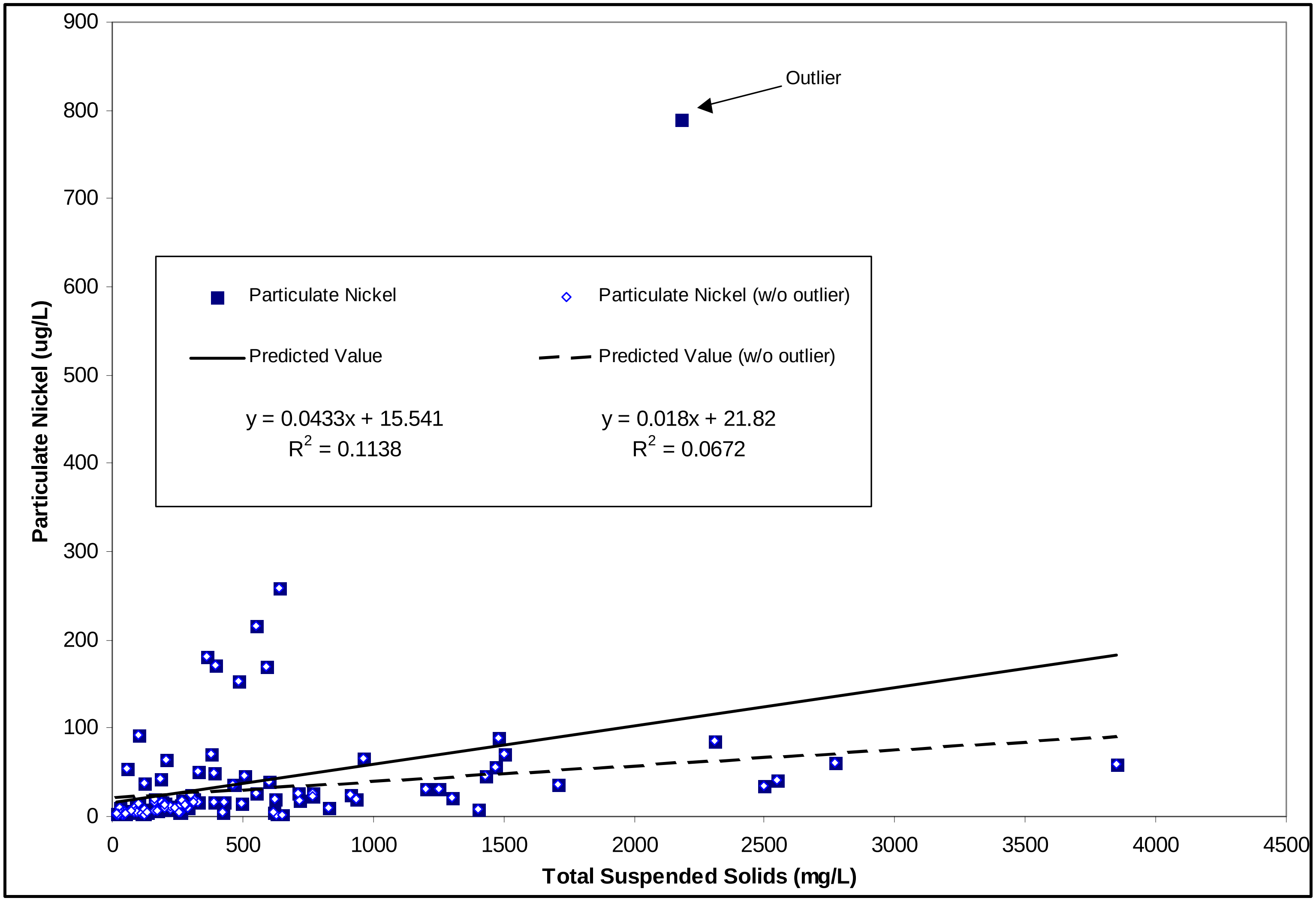


Figure 5-29
Correlation Between TSS and Particulate Nickel for
Construction Site Runoff Characterization Study During the Past Four Years

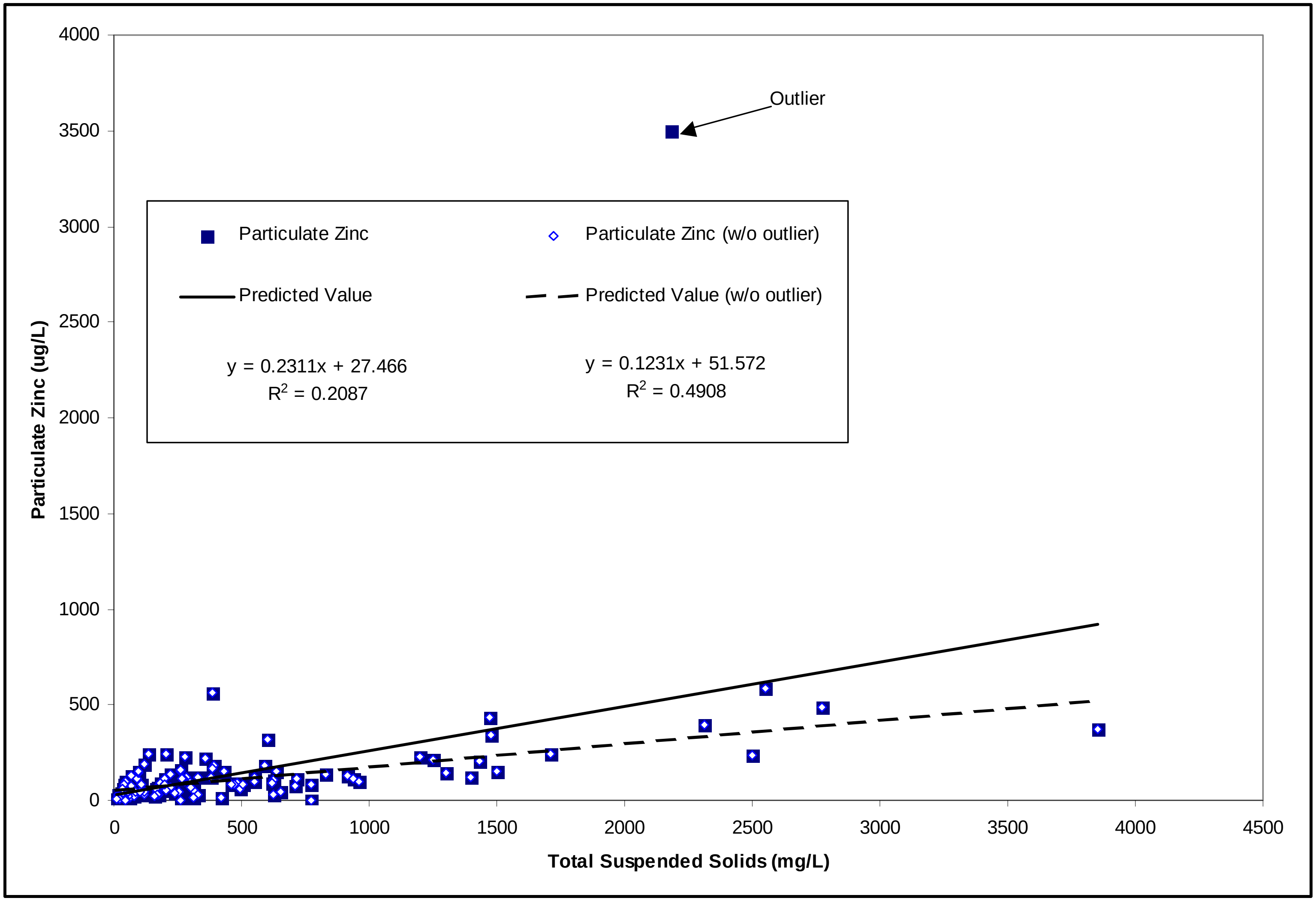


Figure 5-30
Correlation Between TSS and Particulate Zinc for
Construction Site Runoff Characterization Study During the Past Four Years

5.4 Implication of Results

Comprehensive storm water runoff water quality information from construction sites is generally lacking. Therefore, storm water data gathered through this four-year study can serve as suitable water quality information available on runoff from Caltrans construction sites. In addition, this information may be useful for other state transportation agencies and other public and private organizations involved in highway construction activities.

Today, many states are charged with developing waste load allocations as part of their total maximum daily load (TMDL) planning. The four-year study provides mean constituent concentrations as well as the range of constituent concentrations. This is important information which can be used by states in determining likely pollutant loads, and establishing realistic TMDL waste loads allocations from similar construction projects particularly for watersheds with 303d listed water bodies.

Understanding typical pollutant concentrations in construction site runoff can help policy makers and the technical experts who support them to pin-point specific pollutant load issues and recommend subsequent BMP-effectiveness studies to prevent or reduce various pollutant discharges.

Caltrans resident engineers and their staff can benefit from the results of the four-year study. Currently, the Caltrans NPDES permit calls for compliance with the General Construction permit and development of a Storm Water Pollution Prevention Plan (SWPPP) for construction sites with disturbed area of 5 acres or more. By March of 2003, this threshold will be reduced to 1 acre. SWPPP coordinators are designated as part of the resident engineer's staff to verify that the SWPPP is implemented correctly. Knowing which pollutants are most prevalent in construction runoff under various site conditions will help resident engineers and SWPPP coordinators have a better understanding of and investment in the importance of maintaining the integrity of BMPs under Caltrans controls.

Conceptual SWPPPs may be prepared by Caltrans design engineers for later incorporation in the final SWPPP for the construction phase of a Caltrans project. Understanding which pollutants are most prevalent in construction runoff under various site conditions can help designers make decisions about the size and magnitude of recommended temporary BMPs.

Knowing what to expect in terms of typical construction site runoff concentrations can help watershed planners determine the proportion of overall pollutant load from Caltrans construction sites compared to other sources in the watershed.